Literature for Flight Simulator (Motion) Requirements Research

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Preface

This is the yearly snapshot of the literature examined in the framework of the Federal Aviation Administration/Volpe Center Flight Simulator Human Factors Program and entered in an EndNote® database. It describes 1131 documents, 118 more than last year's edition which it replaces. We are making this literature database available to the public because of feedback received from researchers all over the world that it helps their own investigations. The document has been stripped of any notes reflecting subjective assessments of the reviewers. What remains is a collection, with abstracts and keywords, of the literature reviewed in connection with our on-going work on flight simulator fidelity requirements for effective airline pilot training and evaluation.[1] This work is conducted at the United States Department of Transportation Research and Innovative Technologies Administration's John A. Volpe National Transportation Systems Center. The research is supported by the Federal Aviation Administration's Human Factors Research and Engineering Group (ATOP-HF). We thank its Air Carrier Training Program manager Dr. Eleana Edens for her effective guidance and assistance. The need for this work was established by the Voluntary Safety Programs Branch of the FAA's Air Transportation Division (AFS-230). We thank its manager Dr. Thomas Longridge for his insights.

As much as possible, the original abstracts of the documents cited were used. We don't recommend quoting directly from this document, but urge consultation of the original documents. Obvious spelling errors were corrected, and some spellings were Americanized. URLs at the time the documents were entered may have changed. Some documents listed as drafts may now be available in their final version. Any corrections, additions, and suggestions are very welcome and should be e-mailed to Judith.Burki-Cohen@dot.gov.

Many researchers, colleagues, and librarians have contributed to this document, by suggesting, finding, entering, summarizing and interpreting the pieces of literature. Above all, however, we would like to thank Laura Birmingham for the countless hours she has spent with all of the above as well as managing both the electronic database and the hard copies in our archive. We are grateful to Andrea Sparko, Young Jin Jo, Mary J. Townsend (now Lee), Julie Guinn, and Sarah Ulanet for their contributions to earlier versions.

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FAA/Volpe Center Flight Simulator Human Factors Program

[1] Most publications resulting from this work are available at http://www.volpe.dot.gov/hf/pubs.html

Reference Type: Magazine Article
Year: 2002
Title: Refuse-to-crash concept to foil terrorists rejected
Magazine: Air Safety Week
Date: February 4
Keywords: refuse-to-crash, upset recovery training (URT)
URL: http://findarticles.com/p/articles/mi_m0UBT/is_5_16/ai_82493544

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Reference Type: Magazine Article
Year: 2004
Title: Rudder system recommendation could portend more to come
Magazine: Air Safety Week
Date: June 7
Keywords: Airbus A300-600, rudder travel limiter (RTL), upset recovery training (URT)
Abstract: A recommendation to modify the Airbus A300-600 rudder travel limiter (RTL) to prevent excessive aerodynamic loads could be the first of more calls to improve the airplane's rudder control system.

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Reference Type: Magazine Article
Year: 2006
Title: Runway windshear detection moves to the next level
Magazine: Air Safety Week
Date: April 24
Keywords: windshear detection and avoidance, LIDAR Windshear Alerting System (LIWAS)

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Reference Type: Magazine Article
Year: 2008
Title: Gulfstream, Honeywell joins forces on synthetic vision
Magazine: Business Aviation
Pages: 6-6
Date: February 2
Keywords: synthetic vision system (SVS)
Abstract: Gulfstream Aerospace is now offering a synthetic vision system on the four largest aircraft models in its product line, a system that relies on technology developed by Honeywell Aerospace.

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Reference Type: Web Page
Year: 2008
Title: Loss of control
Series Editor: Eurocontrol (content control)
Series Title: SKYbrary
Access Year: 2008
Access Date: August 7
Last Update Date: July 16, 2008
Keywords: loss of control (LOC), upset recovery training (URT)
Notes: SKYbrary is an initiative of EUROCONTROL, ICAO, and The Flight Safety Foundation aimed at developing a comprehensive source of aviation safety information and making it available to users worldwide.

Reference Type: Magazine Article
Year: 2008
Title: Nearly 60 percent of professional pilots fail LOC tests
Magazine: Regional Aviation News
Date: May 26
Keywords: APS Emergency Maneuver Training, loss of control in-flight (LOC-I), upset recovery training (URT)
Abstract: After 50 percent of commercial pilots and nearly 75 percent of general aviation pilots failed to recover from Loss of Control In-Flight (LOC-I) upsets, APS Emergency Maneuver Training, a division of Aviation Performance Solutions LLC (APS), developed unique training to help pilots cope with the leading cause of crash-related fatalities.

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Reference Type: Magazine Article
Year: 2008
Title: Pilot skills in upset recovery need overhaul
Magazine: AirSafety Week
Date: May 12
Keywords: loss of control in-flight (LOC-I), upset recovery training (URT)
Abstract: APS Emergency Maneuver Training recently released research results on the status of pilot skill level in upset recovery, specifically a pilot's ability to deal with Loss of Control In-Flight (LOC-I).
URL: http://findarticles.com/p/articles/mi_m0UBT/is_19_22/ai_n25412891

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Reference Type: Magazine Article
Author: Aarons, Richard
Year: 1997
Title: Take a steady stance on upset training
Magazine: Business & Commercial Aviation
Date: January 1
Keywords: upset recovery training (URT)
URL:
http://www.aviationnow.com/publication/bca/loggedin/AvnowStoryDisplay.do?fromChannel=bca&pubKey=bca&issueDate=1997-01-01&story=xml/bca_xml/1997/01/01/BC_01_01_1997_P1_123.xml&headline=TAKE+A+STEADY+STANCE+ON+UPSET+TRAINING

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Reference Type: Magazine Article
Author: Adams, Rick
Year: 2005
Title: TDs for TAAs
Magazine: Journal for Civil Aviation Training (CAT)
Issue Number: 3
Pages: 20-24
Number of Pages: 4
Keywords: Technically Advanced Aircraft (TAA), Advanced Aviation Training Device (AATD), Non-Zero Flight Time (NZFT), Multi-crew Pilot License (MPL) training
Abstract: Just when you thought they had used up all the possible acronyms, someone comes along with a few new ones (or new meanings for old ones). AATD, MPL, G1000, NZFT. These are more options in training equipment than ever before - choosing the right mix is your decision, writes technology editor Rick Adams.
URL: http://cat.texterity.com/cat/2005-3/

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Reference Type: Magazine Article
Author: Adams, Rick
Year: 2006
Title: Part 60, part deux?
Magazine: Journal for Civil Aviation Training (CAT)
Pages: 14-17
Date: January
Number of Pages: 4
Keywords: low-cost training, ATR, part 60, flight training device (FTD)
Abstract: Industry veterans are taking a fresh look at the roster of approved training devices - at both the airline and primary levels - and pitching some new headings based on evolving technology.
URL: http://cat.texterity.com/cat/2006-1/templates/pageviewer_print?pg=14&pm=4
http://www.mechtronix.ca/c/mech/sim/file_db/cat_magazine_jan_20061.pdf

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Reference Type: Magazine Article
Author: Adams, Rick
Year: 2006
Title: Same ingredients, cheaper package
Magazine: Journal for Civil Aviation Training (CAT)
Issue Number: 6

Pages: 21-24
Abstract: With the squeeze on operational costs throughout the airline industry, many training organizations are looking to save money and time with devices other than a full flight simulator. For some pilots of the new 787, Boeing may eliminate the FFS entirely.
URL: http://mst.texterity.com/cat/2006-6/?pg=5, p. 21

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Reference Type: Journal Article
Author: Adams, Rick
Year: 2007
Title: About turn, it's time to lean forward
Journal: The Journal for Civil Aviation Training (CAT)
Issue: 4
Pages: 12-15
ISSN: 0960-9024
Number of Pages: 4
Abstract: These are exciting times for simulation and training. There are new aircraft on the horizon, from the B787 and A830 to VLJs being developed by Adam Aircraft, Cessna, Eclipse, Honda and Safire, new suppliers of FFSs, increasingly sophisticated FTDs, and disance learning options.

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Reference Type: Magazine Article
Author: Adams, Rick
Year: 2008
Title: A history of simulation: Part I
Magazine: Military Simulation and Training
Issue Number: 4
Pages: 27-28
Abstract: In this first of a series featuring historic technology that significantly advanced the training value of simulation, Rick Adams describes three vignettes.

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Reference Type: Conference Proceedings
Author: Advani, Sunjoo
Year of Conference: 2009
Title: Motion Cueing From Sensation to Sensibility
Conference Name: World Aviation Training Symposium
Conference Location: Orlando, FL
Notes: This was a PowerPoint presentation given at the WATS April 2009 Conference in Orlando

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Reference Type: Conference Paper
Author: Advani, Sunjoo; Hosman, Ruud
Year: 2001
Title: Integrated motion cueing algorithm and motion-base design for effective road vehicle simulation
Conference Name: Driving Simulation Conference
Conference Location: Nice, France
Date: Sept
Number of Pages: 9
Abstract: A strategy for the design of motion cueing in driving simulation is described in this paper. The proposed method aims at addressing the needs of driver perception and control of vehicle motions and, secondly, the kinematic design of simulator motion-bases can be integrated so as to yield training devices

that are optimised for a given training requirement. Through this approach, the simulator is "pre-adjusted" to the needs of the expected training needs by making design decisions early in the design specification phase. As a result, the cues presented to the driver, as well as the capability of the simulator mechanism to generate those cues, are optimised simultaneously and concurrently. Driving simulators could thereby profit from a more effective and efficient use of the motion cueing system.

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Reference Type: Journal Article
Author: Advani, Sunjoo; Hosman, Ruud
Year: 2008
Title: Taking the "E" out of Emotion
Journal: Modeling & Simulation
Volume: 1
Issue: 2
Pages: 10-11
Date: August 2008

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Reference Type: Report
Author: Advani, S. K.
Year: 1991
Title: The basic research simulator programme and the industrial and aerospace community: Opportunities for cooperative research
City: Delft, The Netherlands
Institution: Faculty of Aerospace Engineering, Delft University of Technology
Date: October
Report Number: LR-662
Number of Pages: 72
Keywords: flight simulators, research projects, human factors engineering, flight simulation, degrees of freedom, computer systems hardware, computer systems programs, motion simulation, cockpit simulators, aircraft, foreign technology
Abstract: A new flight simulation facility is being developed as a system specifically designed to investigate certain issues related to vehicle simulation. The three specific areas of interest are: The dynamic behavior and control of motion platforms; The performance of vehicle simulations in a ground-based environment; and the human factors of vehicle operation. The report discusses the configuration of the Basic Research Simulator and outlines the proposed applications of the facility. The benefits to industry are emphasized throughout.

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Reference Type: Conference Paper
Author: Advani, S. K.
Year: 1993
Title: The development of SIMONA: A simulator facility for advanced research into simulation techniques, motion system control and navigation systems technologies
Conference Name: AIAA Flight Simulation Technologies Conference
Conference Location: Monterey, CA
Publisher: American Institute of Aeronautics and Astronautics (AIAA)
Date: August 9-11
Electronic Resource Number: AIAA-93-3574-CP
Author's Title and Affiliation: Assistant Professor/SIMONA Project Leader, Member AIAA, Delft University of Technology, Faculty of Aerospace Engineering, The Netherlands
Number of Pages: 11

Keywords: SIMONA, simulation techniques, motion systems control, navigation systems technologies, six-degrees-of freedom, man-machine interfaces, fixed-wing aircraft, human motion perception research, human visual perception research, motion-drive algorithms, motion platform
Abstract: The design and development of a new technology six-degrees-of-freedom research simulator will incorporate an advanced hydraulic motion system and a light-weight moving platform for outstanding dynamic performance. The primary design goal is to set a new standard for the fidelity of motion simulation. The simulator will become the core of the new International Centre for Research in Simulation, Motion and Navigation Technologies, or "SIMONA." Fundamental research in the SIMONA facility will be aimed towards the development of simulation modeling techniques, for the refinement of motion systems control, and for investigations into pilot interactions and realistic navigation environments. This simulator, now under construction, can be configured to represent a wide variety of vehicles including fixed and rotary-wing aircraft as well as surface vehicles for land and sea operations. This results in a variety of multi-disciplinary research roles for the simulator.

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Reference Type: Appendix
Author: Advani, S. K.
Year: 1998
Title: Appendix B - Motion washout filter reference frames
Pages: 1-5
Type of Work: Appendix to Ph.D. thesis
Number of Pages: 6
Abstract: In the development and application of motion drive laws, a number of reference frames are specified. The aircraft and simulator reference frames are shown below.

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Reference Type: Book
Author: Advani, Sunjoo Kan
Year: 1998
Title: The kinematic design of flight simulator motion-bases
Series Title: Control and Simulation
City: Delft, The Netherlands
Publisher: Delft University Press
Volume: 4
Number of Volumes: 4
Number of Pages: 243
ISBN: 90-407-1671-4
Abstract: (From the back cover of the book) The primary kinematic goal of the flight simulator motion-base is to provide sufficient motion workspace, such that the transformed specific forces and angular accelerations of the aircraft can be presented, but without the actuators achieving their mechanical limits. The workspace is a function of the motion-base architecture, and can be tailored through optimization. In the approach presented here, the minimum required workspace is specified by first synthesizing the motions required by the simulator through the mapping of the six-dimensional trajectory of the predicted simulator motions onto fifteen planar surfaces. Then, the trajectory boundary is approximated by two-dimensional ellipses. These ellipses are composed into an objective function, in the form of a six-dimensional hyper-ellipsoid, representing the shape of the desired workspace. The mechanism is then optimized, by specifying its design variables and their constraints. The optimization, a Linearly-Constrained Quadratic Programming sub-problem, attempts then to fit the hyper-ellipsoid into the workspace of the mechanism while minimizing the actuator lengths. A minimum-dexterity inequality constraint of 0.2 is applied, which prevents the mechanism from approaching architectural or configuration singularities. Following the optimization, the leg clearance and minimum dexterity (with higher resolution than allowed by during the optimization) is checked for the candidate architectures.
It is found that optimizing the position of the gimbal attachment points of the lower frame yields the most significant improvement in the desired flight simulator workspace over current Stewart Platform

architectures. In all cases, the minimum-dexterity constraint is active, and occurs at some combination of the actuators at either their minimum or maximum lengths. In addition to the constraining of the minimum dexterity, a dynamic analysis shows that the consideration of the actuator loads is also important in the selection of a particular motion-base.

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Reference Type: Conference Paper
Author: Advani, S. K.
Year: 2003
Title: Motion cueing - To move, or not to move
Conference Name: Flight Simulation Engineering and Maintenance Conference (FSEMC)
Date: September 18
Author's Title and Affiliation: Director Simulation & Training, Aircraft Development & System Engineering, b.v.
Number of Pages: 2
Abstract: (Executive Summary) The subject of motion cueing in flight simulation is one that has stirred many debates and raised several questions. This is because motion perception itself is not as easily understood as, say, the perception of visual information from the outside-world image, or from the instruments. In fact, the standards that apply to flight simulation contain no standards for the motion cueing. These guidelines are limited to the robotic behavior of the motion system mechanism. The presentation sheds light on motion cueing from a basic point-of-view, explaining some of its origins—and the reason for the huge level of subjectivity. It begins by explaining that motion plays characteristically different roles depending on the task at hand, whether be it a maneuvering task, or a disturbance rejection task. Furthermore, motion directly influences the pilot's skill-based control behavior.
Recent research, as reported in the paper, can now be harnessed in order to improve the quality of simulation, and to bring objectivity to the area of motion cueing. The importance of this stems from the significant variability between simulators. For example, the motion platforms of two B747-400 simulators, built by the same manufacturer, will often respond differently even though the aircraft model outputs driving the motion systems are the same. Subjective tuning of the motion system leads to these variations; however, the inner-loop motion perception and control process of humans is to a great extent sub-conscious. Is one better than another? In order to answer this, we need to develop criteria as well as an objective means of quantifying the motion cues. In fact, since the visual information works with the non-visual information (primarily the vestibular stimuli) to create our self-motion perception, we need a model that integrates these processes, just as our brain does when controlling an aircraft. The presentation also suggests such a model, and how it could be applied to a QTG process. Despite some advances in motion systems, the flight simulation community can benefit greatly by incorporating new knowledge in a practical, beneficial, and cost-saving way. Imagine the day when the motion tuning process becomes an objective one, alleviating the need for ten evaluation pilots—and eleven different opinions. The question "to move, or not to move" is not the relevant question. Understanding how we use motion in the real aircraft, and applying this knowledge cost-effectively in simulation is however the key.
Notes: This is a summary of a presentation.
URL no longer works (9/30/09).
URL: http://www.arinc.com/fsemc/reports/2003/presentations/motion_cueing_advani.pdf

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Reference Type: Conference Paper
Author: Advani, S. K.; Baarspul, M.
Year: 1992
Title: Design philosophies of the basic research simulator
Conference Name: International Council of the Aeronautical Sciences (ICAS)
Conference Location: Beijing, China
Publisher: American Institute of Aeronautics and Astronautics (AIAA)
Date: September 20-25
Electronic Resource Number: A93-14151 03-01

Number of Pages: 10
Abstract: Principles applied to the design of the Basic Research Simulator are discussed and the simulator's hardware is described. Particular attention is given to the simulation of the motion system and of the flight-deck platform. The applications of the Basic Research Simulator facility include its use in the design of advanced hydraulic systems, in motion drive research, in studies related to the improvement of vehicles simulation models, in aircraft systems research, and in human factors research.

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Reference Type: Journal Article
Author: Advani, S. K.; Hosman, R.
Year: 2000
Title: The appliance of science
Journal: Journal for Civil Aviation Training (CAT)
Volume: 2000
Issue: 9
Pages: 40-44
Number of Pages: 5

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Reference Type: Conference Proceedings
Author: Advani, Sunjoo K.; Hosman, Ruud J.A.W.
Year of Conference: 2006
Title: Revising civil simulator standards - An opportunity for technological pull
Conference Name: AIAA Modeling and Simulation Technologies Conference and Exhibit
Conference Location: Keystone, CO
Publisher: American Institute of Aeronautics and Astronautics
Date: August 21-24
Electronic Resource Number: AIAA 2006-6248
Author's Title and Affiliation: Advani: President, International Development of Technology, Overkroetenlaan 162, 4823 KB, Breda, The Netherlands
Hosman: Director, AMS Consult, Dijkgraafstraat 26, 2645 KN, Delfgauw, The Netherlands
Abstract: The ICAO Manual of Criteria for the Qualification of Flight Simulators defines the protocol by which civil flight training simulators are validated. This document is currently undergoing re-vitalization with the aim of improving the compatibility of flight simulator technical criteria with new technology. Part of the revision process is devoted to addressing the process by which the simulator motion cueing is qualified. To date, this part of the qualification has been based on subjective refinements and limited objective testing of the motion base mechanism. Meanwhile, scientific knowledge on human motion perception and control, and technology in motion system design, is rapidly improving, affording opportunities to make relevant objective improvements to the qualification criteria at a time of need from a training perspective.
This paper reviews the current qualification criteria and the motion-related tests that were recently added to it during its previous revision. These tests are examined in terms of their relevance to fidelity in training tasks. The aim is to support the revision of the document by the ICAO working group through reviewing knowledge existing today in the scientific community. Specific areas that require research input are identified.
In addition to reviewing the current technical tests, we also provide recommendations for implementing criteria to capture the requirements for motion cueing.
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Reference Type: Conference Proceedings
Author: Advani, Sunjoo K.; Hosman, Ruud J.A.W.; Potter, Mario

Year of Conference: 2007
Title: Objective motion fidelity qualification in flight training simulators
Conference Name: AIAA Modeling and Simulation Technologies Conference and Exhibit
Conference Location: Hilton Head, SC
Publisher: American Institute of Aeronautics and Astronautics (AIAA)
Date: August 20-23
Electronic Resource Number: AIAA 2007-6802
Author's Title and Affiliation: Advani: President, International Development of Technology (IDT), Breda, The Netherlands
Hosman: AMS Consult, Delfgauw, The Netherlands
Potter: Project Engineer, IDT, The Netherlands
Abstract: This paper proposes a criterion that defines the motion cueing performance of a flight simulator. The long-term aim of such a criterion is to use it to qualify and compare training and engineering simulators. The approach is based on measuring the total gain and phase of the motion cueing system components, which include the motion cueing algorithm, motion system mechanism and transport delay, over a range of frequencies relevant to the type of flight vehicle being simulated. The frequency response of the total motion cueing system is then plotted against the criterion in a modulus - phase distortion plot (Nichols diagram) indicating the end-to-end performance of the system in gain and phase. The performance of four research simulator motion systems was measured and plotted into this format in order to illustrate this approach. The physical properties of these devices are well known and documented. The paper describes the initial experimental results using the proposed approach and the advantages and limitations. This work is aimed to broaden the understanding of motion cueing, to develop objective guidelines for simulator qualification and, in the long run, to simplify the current technical tests.
Author Address: s.advani@idt-engineering.com
r.hosman@amsconsult.demon.nl
m.potter@idt-engineering.com

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Reference Type: Conference Paper
Author: Advani, S. K.; Mulder, J. A.
Year: 1995
Title: Achieving high-fidelity motion cues in flight simulation
Conference Name: AGARD FVP Symposium on "Flight Simulation -- Where are the Challenges?"
Conference Location: Braunschweig, Germany
Publisher: NASA Technical Reports
Date: May 22-25
Author's Title and Affiliation: Delft University of Technology, SIMONA International Research Centre, Kluyverweg 1, 2629 HS Delft, The Netherlands
Number of Pages: 11
Keywords: cues, accuracy, degrees of freedom, dynamic characteristics, flight simulation, flight simulators, motion simulation, motion simulators, robustness (mathematics)
Abstract: The simulation of high-bandwidth manual flight control tasks dictate the use of simulator motion systems for the reproduction of motion cues on the vestibular and neuromuscular-mechanical arm-manipulator system. The reproduction of these cues, with particular emphasis on the lowest possible time delay, is necessary in human perception research, experimental flight control system development studies, as well as in routine flight training. Perfect reproduction of motion cues with ground-based flight simulators is principally impossible due to kinematic limitations inherent to the motion system. Washout filters minimize these effects. The dynamic characteristics of the motion system however lead to two types of control errors: short term, due to finite oil stiffness and line dynamics, as well as limited control valve bandwidth, and long-term, due to complexity of the non-linear motion system dynamics, making compensation of unwanted parasitic errors difficult. This paper will review techniques which increase the performance of six-degrees-of-freedom hydraulic motion systems for flight simulators. Application of pressure-feedback actuator control increases the robustness of the motion system dynamics, hence decreasing the short-term errors. The long-term control errors are addressed by a (separate) robust,

multi-variable motion system controller which provided control signals to the platform with knowledge of the system state and its inherent properties. The total mass and the vertical location of the centre of gravity of the platform influence the time delay (phase lag) and fidelity of the motion system. These properties also limit any such improvements due to design changes in software or hydraulic hardware. As a result of these studies, a fundamentally unique light-weight motion platform design is proposed, making extensive use of advanced composite materials. This is called the SIMONA Research Simulator. With the improvements made to motion cue quality, fundamental research into human perception processes in human perception research, and experimental flight control system development work, will not be influenced by parasitic motions.

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Reference Type: Journal Article
Author: Advani, S. K.; Nahon, M. A.; Haeck, N.; Albronda, J.
Year: 1999
Title: Optimization of six-degrees-of-freedom motion systems for flight simulators
Journal: Journal of Aircraft
Volume: 36
Issue: 5
Pages: 819-826
Date: September-October
Number of Pages: 8
Abstract: The cueing capabilities of a synergistic flight-simulator motion system are limited primarily by the maximum translational and rotational travel allowed by the motion-base. This travel capability, also known as the workspace, is dictated by the kinematic layout of the motion system. Furthermore, the Jacobian matrix, which maps velocities from platform space to joint space, indicates the dexterity of the mechanism, or the mechanical effort needed by the actuators to move the platform. To systematically design unconventional motion bases, a methodology has been developed to analyze arbitrary six-degrees-of-freedom motion systems. The approach is based on an optimization program to determine the optimal layout of the motion system, given the workspace performance objectives and the design constraints. This allows the investigation of unconventional platform geometries and actuator attachment points, thus allowing the designer to tailor the workspace as required by the simulation task, to ensure that a satisfactory dexterity is maintained, and to guarantee that the actuator legs do not interfere mechanically. This paper describes the proposed methodology, and shows examples of its applications, first to generic workspaces, and then to the workspace required for the simulation of a large transport aircraft.

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Reference Type: Conference Paper
Author: Advani, S. K.; van der Vaart, J. C.; Rysdyk, R. Th.; Grosz, J.
Year: 1993
Title: What optical cues do pilots use to initiate the landing flare? Results of a piloted simulator experiment
Conference Name: AIAA Flight Simulation Technologies Conference
Conference Location: Monterey, CA
Publisher: American Institute of Aeronautics and Astronautics (AIAA)
Electronic Resource Number: AIAA-93-3561-CP
Author's Title and Affiliation: Delft University of Technology, Faculty of Aerospace Engineering, Kluyverweg 1, 2629 HS, Delft, The Netherlands
Number of Pages: 9
Abstract: A piloted moving-base simulator study of the landing of a twin-engined executive jet airplane was conducted to find out if pilots also use an optical variable called the Time-To-Contact (TTC) or tau, to time their actions. By manipulating the approach-path angle and the visual speed of the visible runway outline, the influence of the perceived TTC on the initiation of the landing was assessed. Results suggest that pilots indeed use some kind of Tau-margin strategy, but rely on the judgment of absolute height as

well. Further experiments are needed to rule out any influence of prior training on the timing of the flare. Recent work on timing and perception suggests that the amplitude or speed of control actions may be determined by a higher order variable, i.e. the perceived rate of chance of the Time-To-Contact, called Tau-dot. Possible implications of this for further work are mentioned.

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Reference Type: Conference Proceedings
Author: Advani, S. K.; Verbeek, R. J.
Year of Conference: 1994
Title: The influence of platform mass properties on simulator motion system performance
Conference Name: AIAA Flight Simulation Technologies Conference
Conference Location: Scottsdale, AZ
Publisher: American Institute of Aeronautics and Astronautics (AIAA)
Pages: 145-155
Date: August 1-3
Electronic Resource Number: AIAA-94-3418-CP
Author's Title and Affiliation: Advani: Assistant Professor, SIMONA Project Leader, Member AIAA, SIMONA International Research Centre, Delft University of Technology, The Netherlands
Verbeek: Research Assistant, SIMONA International Research Centre, Delft University of Technology, The Netherlands
Number of Pages: 11
Keywords: platform mass properties, simulator motion system performance, mechanical system, hydraulic system, center of mass
Abstract: The dynamic performance of a simulator motion system is to a great extent determined by the mechanical qualities of the motion system hydraulics, the motion control system which provides signals to the actuator servo valves, and also the mass properties of the moving equipment of the simulator placed on the motion system. Quite commonly, in the case of training flight simulators, the center of gravity of the large moving payloads is located far above the motion systems upper gimbals. An investigation, using a complete dynamic model of payload hydraulic motion system, was carried out to quantify the effects of payload mass properties on motion system performance. This paper will review the results obtained from these studies. It is found that the total mass and vertical location of the center of gravity influence the time delays, phase, and parasitic noises of the motion system, and that these properties also limit and further improvements due to design changes in software or hydraulic hardware. By adapting these design considerations, a motion system with inherently higher performance will result. Therefore, a fundamentally new and yet practical light-weight motion platform design is being proposed. This configuration is being introduced in the multi-functional SIMONA Research Simulator of the Delft University of Technology.

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Reference Type: Web Page
Author: Adversity.net
Year: 2003
Title: Part 1: UAL accidents or incidents caused by underqualified quota hires
Series Editor: Adversity.net
Access Date: October 16, 2006
Last Update Date: October 28, 2003
Keywords: upset recovery training (URT), United Airlines flight 863
Abstract: On June 28, 1998 an underqualified United quota hire damned near crashed a loaded Boeing 747-400 into San Bruno outside San Francisco airport. During takeoff he mistook a failed engine for a blown tire on and took very inappropriate actions as a result. There were 307 people aboard United Flight 863, and it cleared San Bruno by only 100 feet, according to the FAA.
Notes: Includes Aviation Safety Reporting System (ASRS) report and Associated Press stories.
URL: http://www.adversity.net/united/1_UAL_incidents.htm

Reference Type: Conference Proceedings
Author: Advisory Group for Aerospace Research and Development (AGARD)
Year of Conference: 1978
Title: Piloted aircraft environment simulation techniques
Conference Name: AGARD Flight Mechanics Panel Specialists' Meeting
Conference Location: Brussels, Belgium
Date: April 24-27
ISBN: AGARD-CP-249
ISBN 92-835-0222-1
Number of Pages: 316
Keywords: flight simulation, human factors engineering, aerial warfare, environment simulation, pilots (personnel), aircraft seats, aircraft, atmospheric models
Abstract: These proceedings consist of the papers presented at the FMP Specialists' Meeting on "Piloted Aircraft Environment Simulation Techniques." An extensive coverage of the subject is presented. The areas examined range from requirements and user experience, through simulation of the atmosphere--including atmospheric models--to assessments of a wide range of visual systems. Also covered are motion systems, 'g' seats and air combat simulators. A comprehensive Technical Evaluation of the meeting appears in AGARD Advisory Report No. 126.
Notes: Some of the individual papers from these proceedings have also been included in this reference list.
Contents:

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Reference Type: Report
Author: Advisory Group for Aerospace Research and Development (AGARD)
Year: 1979
Title: Dynamic characteristics of flight simulator motion systems
City: Neuilly sur Seine, France
Institution: Advisory Group for Aerospace Research and Development (AGARD)
Date: September
Type: Advisory Report
Report Number: AGARD-AR-144
Number of Pages: 40
Keywords: flight simulators, flight simulation, performance, display devices, flight characteristics, flight maneuvers
Abstract: In the last five years, there has been a sharp rise in the number of simulation facilities employing multiple degree-of-freedom motion systems; however, until recently no substantive attempts have been made to measure the performance of these systems. Those measurements that have been made and published have not been made in a uniform way, so that it is difficult to compare different systems. While data on the gross excursions, velocities and accelerations of these systems have been generally available in the literature, dynamic response, noise and other imperfections were usually neither carefully measured nor was information on them widely distributed.
This Advisory Report specifies a uniform method of measuring and reporting motion performance characteristics, developed by a Working Group of the Flight Mechanics Panel of AGARD. Such a uniform method, in addition to aiding system comparison, can assist in system diagnosis and might be used in writing performance specifications. The definitive characteristics selected for system description are

excursion limits, describing function, linearity and acceleration noise, hysteresis, and dynamic threshold, definitions and methods of measurement and display are given, illustrated by measurements on particular motion systems.
This Advisory Report was prepared under the sponsorship of the Flight Mechanics Panel of AGARD.

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Reference Type: Report
Author: Advisory Group for Aerospace Research and Development (AGARD)
Year: 1980
Title: Fidelity of simulation for pilot training
City: Neuilly sur Seine, France
Institution: Advisory Group for Aerospace Research and Development (AGARD)
Pages: 1-60
Date: December
Type: AGARD Advisory Report
Report Number: AGARD-AR-159
Author's Title and Affiliation: North Atlantic Treaty Organization, Advisory Group for Aerospace Research and Development
Recipient's Title and Affiliation: AGARD Aerospace Medical and Flight Mechanics Panels
Number of Pages: 61
Keywords: flight simulation, accuracy, pilot training, psychology, pilots (personnel)
Abstract: Technology is allowing the simulation of increasingly complex flight situations with more and more fidelity. High fidelity generally implies high cost, but high fidelity is not always necessary to obtain satisfactory training. This report addresses the subject of fidelity of simulation for pilot training and provides background to specialists in the multiple disciplines involved. Topics presented in detail are: the training psychologist's views on fidelity of simulation required to train, and methods of assessing this fidelity; the physiologist's survey of pilot cueing mechanisms, in particular those provided by motion or visually induced motion sensations; and the simulator technologist's assessment of existing motion, visual and aircraft mathematical model technology and the characteristics which could be expected to provide high perceptual fidelity.
In each of these disciplines deficiencies were identified in the current ability to relate simulator fidelity to the needs for pilot training and recommendations are made for structuring future efforts.

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Reference Type: Report
Author: Advisory Group for Aerospace Research and Development (AGARD)
Year: 1981
Title: Characteristics of flight simulator visual systems
City: Neuilly sur Seine, France
Institution: Advisory Group for Aerospace Research and Development (AGARD)
Pages: 1-90
Date: May
Type: Advisory Report
Report Number: AGARD-AR-164
Number of Pages: 90
Keywords: flight simulators, flight simulation, color vision, imagery, simulators, visual perception
Abstract: Out-of-the-window visual simulation is a formidable challenge because of the fantastic performance capabilities of the human eye, the impracticability of producing a simulation system matching this performance and the inadequate understanding of how a human uses the visual information in a simulator. There is a continuing task to define the design characteristics that may affect perception of physiological responses, to establish the relative importance of the corresponding visual and physiological effects, and to understand their relationships with the physical continuums of the displays that can now be generated.

This report addresses only a very small part of the total problem, by identifying and defining those physical parameters that characterize the simulator visual system and determine its fidelity. These characteristics are discussed in terms of the three basic categories of spatial, energy and temporal properties, and for each of the parameters there is a description of its effect, a definition of its appropriate units or descriptors, a discussion of methods of measurement and of its use or importance to image quality. There is also a presentation of the experience of the Working Group members regarding the importance of these parameters in accomplishing a given visual task under given conditions. The final chapters of this report present projections of future trends and recommendations for research.

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Reference Type: Conference Proceedings
Author: Advisory Group for Aerospace Research and Development (AGARD)
Year of Conference: 1987
Title: Symposium on motion cues in flight simulation and simulator induced sickness
Conference Name: AGARD Aerospace Medical Panel Symposium
Conference Location: Brussels, Belgium
Date: September 29-October 1
ISBN: AGARD-CP-433
Number of Pages: 204
Keywords: simulator sickness, motion sickness, simulator after-effects, simulator design trends, simulator training
Abstract: These proceedings include seventeen papers, ensuing discussions of the papers, and a Round Table Discussion from the Symposium sponsored by the AGARD Aerospace Medical Panel held in Brussels, Belgium, on September 28 to October 1, 1987.
The frequency of reports of undesirable effects associated with simulator training has increased as simulator usage has increased to offset the higher costs and risks of conducting training in the complex modern aircraft. Review of current and anticipated future trends in simulator design features suggests that additional problems will arise if research on the etiology of simulator-induced motion sickness and other unwanted simulator effects is insufficient to counteract problems before they arise. The objective of this symposium was to examine simulator-induced effects, their operational implications, and their etiology in order to develop ideas for reducing undesired effects. The papers in this symposium address present and anticipated trends in simulator design, a theoretical viewpoint underlying many of the studies of simulator effects, characteristics of simulators associated with undesired effects, surveys of simulator-induced effects, models for the design and evaluation of simulators, and perceptual and neurophysiological functions fundamental to the understanding of simulation. These papers and the accompanying discussion provide a summary of information obtained in recent years on simulation, and guidelines for direction of future research.
Notes: Some of the individual papers from these proceedings have also been included in this reference list.
Contents:

By L. E. Magee, L. Kantor and D. M. C. Sweeney
Simulator Sickness in The Royal Air Force: A Survey - 6
By J. W. Chappelow
Paper 7 Withdrawn
Simulator Sickness in US Army And Navy Fixed-and Rotary-Wing Flight Simulators - 8
By D. W. Gower, M. G. Lilienthal, R. S. Kennedy and J. E. Fowlkes
Session III - Etiological Factors in Simulator-Induced After Effets [sic]
The Use of Vestibular Models for Design and Evaluation of Flight Simulator Motion - 9
By S. R. Bussolari, L. R. Young and A. T. Lee
Motion Cues in Everyday Life - 10
By J. Kriebel, A. Kornhuber and M. Lang
Manifestation of Visual/Vestibular Disruption in Simulators: Severity and Empirical Measurement of Symptomatology - 11
By J. G. Casali and L. H. Frank
Modeling Operator Control Performance and Well-Being as a Function of Simulator Visual and Motion System Transport Delays - 12
By L. H. Frank, J. G. Casali and W. W. Wierwille
Enquête Sur Le Mal Des Simulateurs De Vol Couplée A Une Etude Nystagmographique - 13
Par G. De Heyn, P. De Graff et P. Vandenbosch
Head-Mounted Spatial Instruments: Synthetic Reality or Impossible Dream - 14
By S. R. Ellis, A. Grunwald and M. Velger
Influence of Vection Axis and Body Posture on Visually-Induced Self-Rotation and Tilt -15
By I. P. Howard, B. Cheung And J. P. Landolt
Vection and the Spatial Disposition of Competing Moving Displays - 16
By I. P. Howard, M. Ohmi, W. Simpson, And J. P. Landolt
Session IV - Preventive Medical And Operational Management Of Simulator Induced After-Effects
Cues for Training Vertigo, Providing Suggestions for the Management of Simulator Sickness - 17
By M. E. Norré
Preadaption to the Stimulus Rearrangement of Weightlessness: Preliminary Studies and Concepts for Trainer Designs - 18
By D. E. Parker and M. F. Reschke
Round Table Discussion - RTD

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Reference Type: Book
Author: Advisory Group for Aerospace Research and Development (AGARD)
Year: 1988
Title: Advances in flying qualities
Series Title: AGARD Lecture Series No. 157
City: Neuilly Sur Seine, France
Publisher: AGARD
Keywords: flight characteristics, human factors engineering, France
Abstract: Judging the suitability of an aircraft to safely and effectively perform its mission without undue pilot skill and discomfort is what flying qualities is all about. Central to such judgement, and to the design of suitable aircraft plus flight control systems, is an understanding of what the pilot can do with ease and comfort or conversely what bothers him. The Lectures are designed to impart such understanding to both novice and seasoned practioners in flying qualities and flight control and thereby to provide the bridge required to extend flying qualities requirements from simple classic response aircraft, to the responses attending the use of full-time active control. It also provides a unifying connection among the empirically derived flying qualities requirements of different aircraft types, e.g. fixed and rotary wing. Mathematical models of pilot control behavior are explained. For purposes of ready and universal characterization , the aircraft plus flight control system (plus displays if applicable), is approximately matched by a lower order equivalent system of sufficient bandwidth to be indicative of the pilot's concerns. Some of the pitfalls and benefits of using flight simulators for flight control system development and flying qualities research are exposed and clarified.

Notes: Contents:
Theme
List of Speakers
Introduction and Overview (by I.L. Ashkenas)
Pilot Modeling (by D.T. McRuer)
Pilot Modeling Applications (by I.L. Ashkenas)
Low-Speed Longitudinal Flying Qualities of Modern Transport Aircraft (by H.A. Mooij)
A Second Look at Mil Prime Flying Qualities Requirements (by R.J. Woodcock)
The Optimal Control Pilot Model and Applications (by M. Innocenti)
The Role of Simulation in Flying Qualities and Flight Control System Related Development (by A.G. Barnes)
Bibliography

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Reference Type: Web Page
Author: Aero Innovation Inc.
Title: How do graveyard spirals occur?
Access Year: 2002
Access Date: July 26
Keywords: graveyard spirals, upset recovery training (URT)
Abstract: (first paragraph) In the parlance of flight instructors and flight researchers, the term "graveyard spiral" refers to any high-speed spiral dive, as distinguished from a "graveyard spin" in which the airplane is actually stalled at a low airspeed. A pilot can enter a graveyard spiral in many different ways, including the scenario described by Gillingham and Wolfe (Spatial Disorientation in Flight, USAFSAM TR-85-31, Dec 1986), but most often the entry is subtle rather than violent. The violence typically follows a gentle, unnoticed entry into a banked attitude below the pilot's threshold for angular acceleration, which calls for a brief account of how the inner ear works.
URL: http://www.aero.ca/e_graveyard_spiral.html

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Reference Type: Conference Proceedings
Author: A'Harrah, R. C.
Year of Conference: 1965
Title: Flight simulation, past, present, and future
Conference Name: AIAA 2nd Annual Meeting
Conference Location: San Francisco, CA
Publisher: American Institute of Aeronautics and Astronautics (AIAA)
Date: July 26-29
Electronic Resource Number: AIAA-1965-480
Author's Title and Affiliation: NORTH AMERICAN AVIATION, INC., COLUMBUS DIV., COLUMBUS, OHIO
Keywords: flight simulation, history, overview, visual display, motion cues
Abstract: This paper presents an overview of flight simulation as used in support of today's aerospace research and development programs. The current practices in application of simulation technology in terms of computer support, visual display techniques, and motion provisions are indicated. Pictorial coverage is included for a representative cross section of flight simulation facilities throughout Germany, the United Kingdom, and the United States.

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Reference Type: Magazine Article
Author: AIAA Modeling and Simulation Technical Committee
Year: 2007
Title: Modeling and Simulation

Magazine: Aerospace America
Frequency: Monthly
Pages: 85-85
Date: December
Number of Pages: 1
Keywords: Royal Aeronautical Society (RAeS), Flight Simulation Group (FSG), International Working Group (IWG), International Civil Aviation Organization (ICAO), Manual of Criteria for the Qualification of Flight Simulators (ICAO Doc. 9625), 14 CFR Part 60
Abstract: Work is progressing in the area of simulator qualification standards harmonization.
URL:
http://www.aiaa.org/aerospace/images/articleimages/pdf/Structures,%20Design%20and%20Test1.pdf

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Reference Type: Electronic Article
Author: Air Deccan
Year: 2007
Title: ATR and Air Deccan open joint training center in Bangalore
Keywords: ATR, Air Deccan, Mechtronix, Bangalore training center, Full Flight Trainer (FFT)
Abstract: On the occasion of the Aero India Airshow 2007, ATR and the Indian air carrier Air Deccan today announced the opening of a new joint Training Center in Bangalore in order to prepare future pilots for the ATR fleet of the airline. This center counts a Full Flight Trainer (FFT), the latest generation of flight simulators, developed jointly by ATR and Canada-based Mechtronix.
URL: http://www.atraircraft.com/public/atr/html/press/releases-details.php?aid=575
Access Date: February 8

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Reference Type: Report
Author: Air Line Pilots Association (ALPA)
Year: 1999
Title: Pilot authority and aircraft protections
Series Editor: ALPA Airworthiness Performance Evaluation and Certification Committee
Date: March 1
Author's Title and Affiliation: Committee Chairman: Captain Ron Rogers
Number of Pages: 54
Keywords: envelope protection, upset recovery training (URT)
Abstract: Modern airliners are equipped with many systems designed to protect the aircraft and its occupants from harm. These systems range from simple warning devices to complex envelope protections. The modern Fly-By-Wire (FBW) flight control system with their flight envelope protection features have the potential of offering significant safety benefits over the protection features of aircraft with conventional flight control systems.
The addition of various protection systems has tended to improve airline accident rates over the years. Occasionally however, some of the very systems designed to protect the aircraft have contributed to accidents. This opposite effect of the onboard safety systems seems to be the result of inadequate or incomplete design, or the occurrence of unanticipated events. In those cases where the safety system itself was causal to an accident, the flight crew was often unable to counter the effects of the system. This paper presents a discussion of the evolution of aircraft protection schemes and lessons learned, along with design recommendations for aircraft systems.
URL: http://www.rvs.uni-bielefeld.de/publications/Incidents/DOCS/Research/Other/Article/RogReports/Rogers_99_Acft_Protect.pdf

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Reference Type: White Paper
Author: Air Line Pilots Association (ALPA)
Year: 2009
Title: Producing a professional airline pilot
Pages: 1-23
Date: September
Abstract: Since the tragic events of September 11, 2001, a number of factors have converged that challenge the assumptions underlying the current processes used for airline pilot screening, hiring, training, and mentoring. The purpose of this paper is to explore the status quo and offer recommendations on ways in which regulators and industry can work together to improve the way industry produces professional airline pilots.
The fallout from September 11 – consolidation, changes in consumer travel habits, and economic uncertainty – has altered the business models of the mainline airlines. These business models now include branded networks that include a greater level of flying being performed by their regional feed partners. Code sharing and fee-for-departure (FFD) agreements create a larger virtual network, and when passengers purchase tickets from a mainline airline, it is very likely, if not certain, that one of their flights will be on a code-share or FFD partner of that airline. Passengers deserve, but in many cases are not receiving, an equivalent level of safety when buying a mainline ticket and flying on code-share or FFD aircraft.
This same industry turmoil has had a negative effect on the desirability of the airline pilot career. Career quality and uncertainty combined with a markedly changed pilot-hiring pool has created additional challenges for airline-pilot hiring practices. In short, many pilots in the current pool of applicants lack the level of experience that generations of pilots ahead of them had when they came into the airlines. In many cases, airlines have not adjusted to hiring less experienced pilots resulting in deficiencies in airline pilot applicant screening, as well as subsequent pilot training and mentoring and ultimately pilot performance. Pilot qualification requirements and regulator oversight of airline pilot training in the United States and Canada have not kept pace with these industry changes.
Today's archaic regulations allow airlines to hire low-experience pilots into the right seat of high-speed, complex, swept-wing jet aircraft in what amounts to on-the-job training with paying passengers on board. Investigations of recent accidents reveal that safety margins have been eroded at some carriers as a result.
A complete overhaul of pilot selection and training methods is needed. A number of recommendations are made herein that can be effectively used to restore the use of pilot applicant screening processes, institute enhanced training methods, procedures, and devices, as well as increase mentoring of pilots by their more experienced colleagues.

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Reference Type: Electronic Article
Author: Air Safety Week
Year: 2002
Title: Upset recovery training and the potential for negative learning
Periodical Title: Air Safety Week
Issue: November 11
Keywords: negative training, negative learning, upset recovery training (URT)
URL: http://findarticles.com/p/articles/mi_m0UBT/is_43_16/ai_94139244

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Reference Type: Report
Author: Aircraft Certification Office (ASO)-205
Year: 1991
Title: Airplane simulator qualification
Institution: Federal Aviation Administration (FAA)
Date: July 29
Type: Advisory Circular

Report Number: Advisory Circular AC 120-40B
Number of Pages: 74
Keywords: airplane simulator qualification, validation, National Simulator Program Manager, NSPM
Abstract: Lists one of the means of compliance with the Federal Aviation Regulations (FAR) regarding the evaluation and qualification of airplane simulators used in training program [Incomplete abstract].
Notes: See also AC 120-40C; See also Part 60, Flight Simulation Training Device Initial and Continuing Qualification and Use; See also AFS-205 (2003), Alternate means for airplane simulator qualifications incorporating Revision 2 to the ICAO Manual of Criteria for the Qualification of Flight Simulators.
URL:
http://www.airweb.faa.gov/Regulatory_and_Guidance_Library/rgAdvisoryCircular.nsf/0/5B7322950DD10F6B862569BA006F60AA?OpenDocument&Highlight=120-40b

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Reference Type: Report
Author: Aircraft Certification Office (ASO)-205
Year: 1992
Title: Airplane flight training device qualification
City: Washington, DC
Institution: Federal Aviation Administration (FAA)
Date: February 5
Type: Advisory Circular Draft
Report Number: AC 120-45A
Recipient's Title and Affiliation: Federal Aviation Administration, 800 Independence Avenue, S.W., Washington, DC 20591
Keywords: airplane simulator, flight training device, approval of flight training device, approval test guide, cockpit, convertible flight training device, evaluation of flight training device, latency, National Simulator Program Manager, operator, qualification, replica, set of airplanes, simulation data, simulator evaluation specialist, snapshot statement of compliance, time history, transport delay, upgrade
Abstract: This Advisory Circular (AC) provides an acceptable means, but not the only means, of ensuring compliance with the Federal Aviation Regulations (FAR) regarding the evaluation and qualification of all training devices in which flight training, qualification, or certification of airmen under Title 14, Code of Federal Regulations is accomplished. These devices are referred to in this document and other documents published by the Federal Aviation Administration (FAA) as "flight training devices." This AC specifies the criteria to be used by the FAA when qualifying a device and determining what the qualification level should be. While these guidelines are not mandatory, they are derived from extensive FAA and industry experience in determining compliance with the pertinent FAR. Mandatory terms used in this AC such as "shall" or "must" are used only in the sense of ensuring applicability of this particular method of compliance when the acceptable method of compliance described herein is used. Applicable regulations must also be referenced to assure compliance with provisions herein. This AC does not change regulatory requirements or create additional ones, and does not authorize changes in, or deviations from, regulatory requirements. The provisions of the FAR are controlling. This document does not interpret the regulations. Interpretations are issued only under established agency training devices described in this paragraph and further defined in paragraph 6b. Guidance of the evaluation of simulators is published in AC120-40, Airplane Simulator Qualifications, as amended.
Notes: Cancelled by AC 61-TD.
This document contains a relevant definition list for many terms associated with flight training and simulators. Also contains appendices on flight training device standards, flight training device validation tests, and functional and subjective tests.
Replaces 120-45.
URL:
http://www.airweb.faa.gov/Regulatory_and_Guidance_Library/rgAdvisoryCircular.nsf/0/2E57CFE51107AFE6862569E00073603A?OpenDocument

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Reference Type: Report
Author: Aircraft Certification Office (ASO)-205
Year: 1995
Title: Airplane flight training device qualification
Institution: Federal Aviation Administration (FAA)
Date: August 28
Type: Advisory Circular Draft
Report Number: 120-45B
Label: Draft
Keywords: airplane flight training device qualifications, validation data

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Reference Type: Report
Author: Aircraft Certification Office (ASO)
Year: 1991
Title: FAR 135 training program outline
Institution: Federal Aviation Administration (FAA)
Type: Advisory Circular Draft
Number of Pages: 16

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Reference Type: Electronic Article
Author: Aircraft Owners and Pilots Association (AOPA)
Year: 1999
Title: PCATD
Periodical Title: Safety Advisor
Volume: 2007
Issue: Feb. 5
Number of Pages: 18
Keywords: Personal computer aviation training devices (PCATD)
Abstract: Personal computer-based training is making good pilots better.
URL: http://www.aopa.org/asf/publications/sa10.html
Access Date: March 27, 2002

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Reference Type: Report
Author: Aircraft Owners and Pilots Association (AOPA) Air Safety Foundation
Year: 2003
Title: Stall/spin: Entry point for crash and burn?
Series Editor: AOPA
City: Frederick, MD
Institution: AOPA Flight Safety Foundation
Author's Title and Affiliation: Publisher: Bruce Landsberg
Editors: Kristen Hummel & Kevin Murphy
Statistician: Kristen Hummel
Number of Pages: 6
Keywords: upset recovery training (URT), stall, spin
Abstract: Pilots who believe that aerobatic training will enable a recovery from an inadvertent spin in the traffic pattern are fooling themselves. That myth -- and other misconceptions about stalls and spins in GA aircraft -- is explored in this new ASF study. This study is not intended to discount the value of properly conducted aerobatic and spin training. Training in a controlled environment with a trained instructor is beneficial. The most important aspect of the training should be recognition and prevention.

Stall/spin accidents tend to be more deadly than other types of GA accidents, accounting for about 10 percent of all accidents, but 13.7 percent of fatal accidents. Overall, around 20 percent of all GA accidents result in fatalities, but stall/spin accidents have a fatality rate of about 28 percent.
URL: http://www.aopa.org/asf/publications/topics/stall_spin.pdf

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Reference Type: Web Page
Author: Airmanship On-line
Year: 2000
Title: Le prime notizie del disastro del Concorde dell'Air France le appresi attraverso la radio mentre ero in autostrada
Access Year: 2006
Access Date: October 19
Edition: Fall
Keywords: Air France Concorde accident, blown tires, upset recovery training (URT)
Abstract: Reflections on the disaster of the Concorde.
Notes: The first few pages are in Italian, the rest in English.
URL: http://www.airmanshiponline.com/fall2000/06-Disastrol%20Concorde%20.htm

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Reference Type: Web Page
Author: Airplanes
Year: 1999
Title: Jetstream 41
Type of Medium: Printouts of information on the Jetstream 41
Abstract: <u>Product Background</u>
The Jetstream 41 is a major development of the highly successful Jetstream 21/23 family. The J41 is operating throughout the world in 29/30 seat commuter and 14-seat corporate shuttle configurations.

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Reference Type: Conference Paper
Author: Albery, W. B.; Gum, D. R.; Kron, G. J.
Year: 1978
Title: Motion and force cueing requirements and techniques for advanced tactical aircraft simulation
Conference Name: Flight Mechanics Panel Specialists' Meeting on Piloted Aircraft Environment Simulation Techniques
Conference Location: Brussels, Belgium
Publisher: Advisory Group for Aerospace Research and Development (AGARD)
Date: April 24-27
Author's Title and Affiliation: Albery: Electronics Engineer, Simulation Techniques Branch, Air Force Human Resources Laboratory, Advanced Systems Division, AFHRL/ASM, Wright-Patterson AFB, OH 45433
Gum: Chief, Simulation Techniques Branch, Air Force Human Resources Laboratory, Advanced Systems Division, AFHRL/ASM, Wright-Patterson AFB, OH 45433
Kron: Senior Staff Engineer, Link Division, Dept 495, Singer Company, Binghamton, NY 13901
Number of Pages: 10
Keywords: motion and force cueing, advanced tactical aircraft simulation, motion sensory mechanism, time delays, g-seat, g-suit, g-cueing
Abstract: The approach being pursued by the US Air Force to advance motion and force cueing technology for tactical air flight simulators is twofold. The first part includes efforts directed toward building a data base on which to base motion and force cueing requirements. The second part includes efforts to improve the performance of existing devices that have been shown to be somewhat effective and to develop new devices and techniques as indicated by the data base efforts. The data base development

involves looking at the pilot who receives motion and force cues and the aircraft and environment which impart the motion and force cues. Models of human motion and force sensory mechanisms (vestibular, tactile, visual, motion and nonvestibular proprioceptive) describing how motion is perceived have been developed and the motion and force environment for tactical aircraft performing various maneuvers is being characterized. The results of the environment for this are being used to define motion and force cueing requirements and concepts for new devices to impart the necessary cues. Cueing device development efforts include the development of the next generation g-cueing (g-seat, g-suit, and benefit) system with improved response and onset cueing capability; the techniques for myoelectric control of visual simulation system brightness and field-of-view as a function of the g-force environment and pilot physical action; and design for the systems such as arm, thigh, and head loading devices to provide for simulation of the extremely high-g flight environment.

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Reference Type: Magazine Article
Author: Allan, Roger
Year: 2004
Title: Making the skies safer
Magazine: Electronic Design
Date: May 24
Keywords: windshear detection and avoidance system
Abstract: An intensive seven-year effort by NASA researchers led to a sophisticated wind-shear detection and avoidance system that is just now boarding commercial aircraft in volume.
URL: http://electronicdesign.com/Articles/Print.cfm?ArticleID=8013

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Reference Type: Journal Article
Author: Allen, John A.; Hays, Robert T.; Buffardi, Louis C.
Year: 1986
Title: Maintenance training simulator fidelity and individual differences in transfer of training
Journal: Human Factors
Volume: 28
Issue: 5
Pages: 497-509
Author's Title and Affiliation: Allen: George Mason University, Fairfax, VA
Hays: U.S. Army Research Institute for the Behavioral and Social Sciences, Alexandria, VA
Buffardi: George Mason University, Fairfax, VA
Number of Pages: 13
Keywords: training effectiveness, simulator, fidelity
Abstract: This study was undertaken to investigate the relationship between simulator fidelity and training effectiveness. Two aspects of simulator fidelity were manipulated, namely, the degree to which a training simulator "looked like" actual equipment (physical fidelity), and the extent to which it "acted like" real equipment (functional fidelity). A transfer of training design was used to assess learning. Performance on an electromechanical troubleshooting task was correlated with a number of individual difference variables. Results indicated that physical and functional fidelity were interdependent and that temporal measures were most sensitive to fidelity manipulations. Low functional fidelity was associated with longer problem solution and inter-response times. Persons with high analytic abilities took longer to solve problems, but required fewer troubleshooting tests and made fewer incorrect solutions.

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Reference Type: Report
Author: Allen, W. R.; DiMarco, R. J.
Year: 1984
Title: Effects of transport delays on manual control system performance

Institution: National Aeronautics and Space Administration (NASA)
Report Number: NASA CP-2341 Vol. 1
Keywords: transport delay, manual control system
Abstract: Throughput or transport delays in manual control systems can cause degraded performance and lead to potentially unstable operation. With the expanding use of digital processors, throughput delays can occur in manual control systems in a variety of ways such as in digital flight control systems in real aircraft, and in equation-of-motion computers and CGI's in simulators. Previous research has shown the degrading effect of throughput delays on subjective opinion and system performance and dynamic response. A generic manual control system model is used in this paper to provide a relatively simple analysis of and explanation for the effects of various types of delays. The consequences of throughput delays of some simple system architectures were also discussed.

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Reference Type: Film or Broadcast
Director: Allied Pilots Association (APA)
Year Released: 1998
Title: Highways in the sky: Aviation on the road ahead
Distributor: Entertainment Design Workshop
Medium: Videotape

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Reference Type: Report
Author: Allied Pilots Association (APA)
Year: 2004
Title: Submission of the Allied Pilots Association to the National Transportation Safety Board regarding the accident of American Airlines flight 587 at Belle Harbor, New York November 12, 2001
Date: March 24
Report Number: NTSB DCA02MA001
Number of Pages: 32
Keywords: American Airlines flight 587, upset recovery training (URT)
Abstract: (from Introduction) In order for the reader to best understand the complex factors of the AA 587 accident, the Facts, Analyses and Recommendations portion of this report is divided into four main areas:
- Flight Control System
- Flight Environment
- Adverse Aircraft Pilot Coupling
- Oversight

Each section contains facts and analysis followed by recommendations.
This was a complex accident. The Allied Pilots Association (APA) offers this Submission to aid the Safety Board in its analysis. Suggestions for specific safety recommendations that APA believes should be a part of the Final Report are compiled at the end of the report.

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Reference Type: Conference Paper
Author: Allsopp, W. J.
Year: 1978
Title: Proposed advancements in simulation of atmospheric phenomena for improved training
Conference Name: AGARD Flight Mechanics Panel Specialists' Meeting on Piloted Aircraft Environment Simulation Techniques
Conference Location: Brussels, Belgium
Publisher: Advisory Group for Aerospace Research and Development (AGARD)
Date: April 24-27
Author's Title and Affiliation: Senior Engineering Test Pilot & Senior Instructor Pilot, The Boeing Company, P.O. Box 3707, Seattle, WA 98124

Number of Pages: 11
Keywords: simulation of atmospheric phenomena, visual systems
Abstract: Obviously, flight simulators are a major training vehicle and the desire to reduce in-airplane training is the driving force to obtain better flight simulator visual systems. As the result of both commercial and military applications, major advancements were made in simulator visual systems, resulting in commercial use of the various electronically generated visual systems. Improvements appear to be required in many areas, such as field of view, resolution, brightness, scene content, lights, visual/motion integration, simulated airplane short-period response, and atmospheric environment. The latter is the subject of this paper.

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Reference Type: White Paper
Author: ALPA
Year: 2007
Title: Safety Committee Statement of Position: The need for motion in flight simulation
URL:
http://crewroom.alpa.org/SAFETY/DesktopModules/ALPA_Documents/ALPA_DocumentsView.aspx?itemid=13552&ModuleId=13545&Tabid=3205
Author Address: Air Line Pilot Association
1625 Massachusetts Avenue, N.W.
Washington, D.C. 20036
703-481-4440
WWW.ALPA.ORG

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Reference Type: Electronic Article
Author: American Airlines; Airbus
Year: 2004
Title: Point/counterpoint - The Airbus position - Extracts
Periodical Title: Air Safety Week
Issue: March 29
Keywords: American Airlines flight 587, upset recovery training (URT), negative training
Abstract: (first two paragraphs)
'Negative Training'
Probable cause:
The probable cause of the accident involving AA [American Airlines] 587 was the structural overload of the vertical stabilizer induced by the inappropriate and unnecessary application of cyclic, stop-to-stop inputs to the rudder pedals by the first officer in anticipation of what he mistakenly believed would be the aircraft reaction to an encounter with a wake vortex.
This mistaken belief and the consequent inappropriate and unnecessary pilot actions were conditioned elements of American Airlines' AAMP that advocated the aggressive use of rudder for roll control. This was reinforced by negative training generated by American Airlines' modifications of the A300-600 training simulator that resulted in temporary inhibition of normal roll control functions such that pilots were forced to use rudder as a primary means of roll control to recover from simulated wake vortex encounters.
URL: http://findarticles.com/p/articles/mi_m0UBT/is_13_18/ai_114714587
Access Date: October 16, 2006

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Reference Type: Conference Proceedings
Author: American Institute of Aeronautics and Astronautics (AIAA)
Year of Conference: 2000
Title: Proceedings of the Modeling and Simulation Technologies Conference and Exhibit

Conference Name: Modeling and Simulation Technologies Conference and Exhibit
Conference Location: Denver, CO
Publisher: American Institute of Aeronautics and Astronautics (AIAA)
Date: August 14-17

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Reference Type: Conference Proceedings
Author: Amery, J. G.; Streid, H.
Year of Conference: 1999
Title: Flight simulation visual requirements and a new display system
Editor: Hopper, Darrel G.
Conference Name: International Society for Optical Engineering (SPIE)
Volume: 3690
Pages: 356-367
Series Editor: Hopper, Darrel G.
Series Title: Cockpit Displays VI: Displays for Defense Applications
Date: April 7-9
Author's Title and Affiliation: The Boeing Company
John G. Amery: M/S S064 1481 Flight Simulation Technology
Harry Streid: M/S S106 4685 Aerospace Training & Support Systems
Keywords: simulation, out-the-window, flat panel display, COTS, continuous mosaic display, cost effective
Abstract: This paper reviews the technical requirements for Out The Window (OTW) visual systems. Requirements for different modes of training and/or simulation will be stated. A new type of visual display will be described that provides improved, cost effective implementation and performance.
URL: http://www.rickleephoto.com/mosaicfresnel.htm
Author Address: The Boeing Company, PO Box 516, St. Louis, MO 63166-0516

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Reference Type: Conference Paper
Author: Anderson, G. R.
Year: 1985
Title: A method for aircraft simulation verification and validation developed at the United States Air Force Flight Simulation Facility
Conference Name: Flight Mechanics Panel Symposium on Flight Simulation
Conference Location: Cambridge, United Kingdom
Publisher: Advisory Group for Aerospace Research and Development (AGARD)
Date: September 30-October 3
Author's Title and Affiliation: 1LT, USAF, Simulation Engineer, 6520 Test Group, Air Force Flight Test Center, Edwards, CA 93523-5000
Number of Pages: 7
Keywords: verification, validation, USAF
Abstract: The flight simulators at the USAF Flight Test Center (AFFTC) Aircraft Flight Simulation Facility (AFSF) are primarily used for performance and flying qualities studies. These high-fidelity, real-time simulators are used as an engineering tool during the flight development of the new or modified aircraft. Emphasis is placed on fully developing, verifying and validating a simulation before the actual aircraft begins flight testing. The flexibility, accuracy and ease with which the facility's method of verification and validation can be learned and implemented are a few of its advantages. This is demonstrated by the number of simulators which have been developed using it. The F-15 A/B, B-1B, Shuttle, F-15 C/D, AFTI (Advanced Fighter Technology Integration), F-16, F-16 C/D and the T-46 are examples of simulations presently operational at the facility which were developed using the AFSF's method.
The Philosophy of developing a simulation before flight test allows the most to be learned about the aircraft before testing begins. The "test smarter" approach taken at the AFFTC requires that aircraft

simulations be built quickly and be used to make flight testing more efficient and safer. The methods for verifying and validating simulations used at the AFSF assure that these requirements are fulfilled.
Notes: Published in September 1986.

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Reference Type: Journal Article
Author: Andreassi, J. L.; Greco, J. R
Year: 1975
Title: Effects of bisensory stimulation on reaction time and the evoked cortical potential
Journal: Physiological Psychology
Volume: 3
Issue: 2
Pages: 189-194
Author's Title and Affiliation: Baruch College, City University of New York, 155 East 24th Street, New York, NY 10010
Number of Pages: 6
Abstract: Reaction times and evoked cortical potentials to visual and auditory stimuli alone and to the two in combination (bisensory stimulation) were studied. It was found that bisensory stimulation resulted in significantly faster reaction times than those obtained with visual or auditory stimulation alone. Auditory reaction times were faster than visual. The amplitudes of evoked potentials were significantly higher at both recording times (O_2 and C_2) under conditions of bisensory as compared to unisensory stimulation. Evoked potential latencies were in the expected direction, i.e., all conditions using auditory stimulation resulted in shorter latencies than the visual stimulation alone condition. It was concluded that evidence for sensory interaction (facilitative) had been obtained in this experiment and that the amplitude increases with bisensory stimulation were reflected in faster reaction times. A definitive statement regarding the central nervous system locus of this sensory interaction is not yet possible.

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Reference Type: Magazine Article
Author: Anselmo, Joseph C.
Year: 2006
Title: CAE Neighbor Is Newest Competitor
Magazine: Aviation Week & Space Technology
Pages: 53-53
Date: December 4
Type of Article: part of section on Simulation and Training
Number of Pages: 1
Abstract: Mechtronix takes on giant CAE by targeting smaller airlines.
Notes: Part of section on Simulation and Training. All articles in this section include:
Fighting human error (F. Fiorino)
Retooling maintenance lessons (L. A. Tegtmeier)
Getting upset (E. H. Phillips)
A little competition (J. C. Anselmo)
Ready, VLJet, go (F. Fiorino)

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Reference Type: Book Section
Author: Anstis, Stuart M.
Year: 1986
Title: Visual-vestibular interactions: Effects on self-motion perception and postural control
Editor: Held, R.; Leibowitz, H. W.; Teuber, H.-L.
Book Title: Handbook of Sensory Physiology: Perception
City: New York
Publisher: Springer Verlag
Volume: 8

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Reference Type: Presentation
Author: Aoki, Hirofumi; Oman, Charles M.; Natapoff, Alan; Buckland, Dan; Liu, Andrew
Year: 2006
Title: The effect of configuration, frame of reference, and spatial ability on spatial orientation during 3-dimensional navigation training
Presentation Event: 7th Symposium on the Role of the Vestibular Organs in Space Exploration
Event Location: The Netherlands
Date: June 7-9
Author's Title and Affiliation: Man-Vehicle Laboratory, Massachusetts Institute of Technology (MIT)
Keywords: spatial orientation, upset recovery training (URT)

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Reference Type: Conference Paper
Author: Ashkenas, Irving L.
Year: 1985
Title: Collected flight and simulation comparisons and considerations
Conference Name: Flight Mechanics Panel Symposium on Flight Simulation
Conference Location: Cambridge, United Kingdom
Publisher: Advisory Group for Aerospace Research and Development (AGARD)
Date: September 30 - October 3
Author's Title and Affiliation: Vice President, Systems Technology, Inc., 13766 S. Hawthorne Boulevard, Hawthorne, CA 90250
Number of Pages: 34
Keywords: fidelity, perceptual, motion, tracking, failure detection, field-of-view
Abstract: Government-sponsored research at Systems Technology, Inc. dealing with simulation fidelity and utility is reviewed, starting with some generic effects of motion and vision system characteristics and of computational artifacts. Diagnostic methods and tools useful in discovering and delineating significant qualitative and quantitative differences between simulation and flight are then exposed and illustrated. Finally examples of both fixed and moving simulation successes and shortcomings are reviewed and examined as to root causes of either. The research-simulator equipment involved in the above comparison ranges from modeling large-scale motion systems and computer-generated imagery to fixed-base with simple CRT-generated displays.
Notes: Published in September 1986.

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Reference Type: Report
Author: Ashworth, Billy R.; McKissick, Burnell T.; Parrish, Russell V.
Year: 1984
Title: Effects of motion base and g-seat cueing on simulator pilot performance
City: Hampton, VA
Institution: National Aeronautics and Space Administration (NASA), Langley Research Center
Date: March

Type: Technical Report
Report Number: NASA TP-2247
Keywords: motion cue, g-seat cue, simulation, tracking error
Abstract: In order to measure and analyze the effects of a motion plus g-seat cueing system, a manned-flight-simulation experiment was conducted utilizing a pursuit tracking task and an F-16 simulation model in the NASA Langley Visual/Motion Simulator. This experiment provided the information necessary to answer the primary question; do motion and g-seat cues have an additive effect on the performance of this task? With respect to the lateral tracking error and roll-control stick force, the answer is affirmative. In this paper it is shown that presenting the two cues simultaneously caused significant reductions in lateral tracking error and that using the g-seat and motion base separately provided essentially equal reductions in the pilot's lateral tracking error.

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Reference Type: Generic
Author: ASME International
Year: 2000
Title: The Link flight trainer: A historic mechanical engineering landmark
Date: June 10
URL: http://files.asme.org/ASMEORG/Communities/History/Landmarks/5585.pdf

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Reference Type: Report
Author: Aviation Flight Standards (AFS)-200
Year: 1991
Title: Crew qualification and pilot type rating requirements for transport category aircraft
Institution: Federal Aviation Administration (FAA)
Date: May 13
Type: Advisory Circular
Report Number: 120-53
Keywords: transport category aircraft, rating requirements, crew qualification
URL:
http://www.airweb.faa.gov/Regulatory_and_Guidance_Library/rgAdvisoryCircular.nsf/0/C9574229A4AAB7E9862569EA00695F04?OpenDocument&Highlight=120-53

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Reference Type: Report
Author: Aviation Flight Standards (AFS)-205
Year: 1994
Title: Helicopter simulator qualification
Institution: Federal Aviation Administration (FAA)
Date: October 11
Type: Advisory Circular
Report Number: AC 120-63
URL:
http://www.airweb.faa.gov/Regulatory_and_Guidance_Library/rgAdvisoryCircular.nsf/0/B56F9F7D967AFFBB862569E000736080?OpenDocument&Highlight=120-63

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Reference Type: Report
Author: Aviation Flight Standards (AFS)-205
Year: 1995
Title: Airplane simulator qualification
Institution: Federal Aviation Administration (FAA)
Date: July 1
Type: Advisory Circular Draft
Report Number: 120-40C
Label: Draft
Keywords: simulator data requirements, simulator standards, validation tests
Abstract: Contains numerous appendices for qualifications based on wind shear, validation tests, simulator standards, functions and subjective tests

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Reference Type: Report
Author: Aviation Flight Standards (AFS)-205
Year: 2003
Title: Alternate means for airplane simulator qualifications incorporating Revision 2 to the ICAO Manual of Criteria for the Qualification of Flight Simulators
Institution: Federal Aviation Administration (FAA), National Simulator Program
Date: September 12
Type: FSTD Guidance Bulletin draft
Notes: On 9/30/09, the URL no longer works.
URL:
http://www.faa.gov/safety/programs_initiatives/aircraft_aviation/nsp/flight_training/bulletins/media/03-13.doc

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Reference Type: Report
Author: Aviation Flight Standards (AFS)-210
Year: 1991
Title: Crewmember cabin safety training
Institution: Federal Aviation Administration (FAA)
Type: Advisory Circular Draft
Report Number: AC120-51A DRAFT
Number of Pages: 6
Notes: This version has been canceled and replaced.

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Reference Type: Report
Author: Aviation Flight Standards (AFS)-210
Year: 1994
Title: Use of airplane flight training devices; Inflight checking and training for airman qualification and certification
Institution: Federal Aviation Administration (FAA)
Date: October 11
Type: Advisory Circular
Report Number: 120-46A
Number of Pages: 6
Keywords: use of airplane flight training devices, inflight training and checking for airman qualification and certification, authorizations, old vs. new training device and simulator qualification level terminology

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Reference Type: Report
Author: Aviation Flight Standards (AFS)-210
Year: 1995
Title: Crew resource management training
Institution: Federal Aviation Administration (FAA)
Date: March 1
Type: Advisory Circular
Report Number: 120-51B
Number of Pages: 28
Notes: AC 120-51A, Crew Resource Management Training, dated 2/10/93, has been canceled.

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Reference Type: Report
Author: Aviation Flight Standards (AFS)-210
Year: 2004
Title: Line operational simulation: Line-oriented flight training, special purpose operational training, line operational evaluation
Institution: Federal Aviation Administration (FAA)
Type: Advisory Circular
Report Number: AC 120-35C
URL:
http://www.airweb.faa.gov/Regulatory_and_Guidance_Library/rgAdvisoryCircular.nsf/0/B86DE77A355EA57B86256F25006D977A?OpenDocument&Highlight=ac%20120-35b

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Reference Type: Report
Author: Aviation Flight Standards (AFS)-800
Title: FAA Approval of Basic Aviation Training Devices (BATD) and Advanced Aviation Training Devices (AATD)
City: Washington, DC
Institution: Federal Aviation Administration (FAA)
Type: Advisory Circular
Report Number: AC 61-TD
Number of Pages: 31
Keywords: Advisory Circular, Basic Aviation Training Devices (BATD), Advanced Aviation Training Devices (AATD)
Abstract: This AC provides information and guidance relevant to the performance and the effective use of ATDs for pilot training or certification, other than for aircraft type-specific training or for an aircraft type rating.
Notes: Draft (on concurrence as of 12/13/06). Cancels AC 61-126, Qualification and Approval of Personal Computer-Based Training Devices (PCATD), dated May 12, 1997; and AC 120-45, Airplane Flight Training Device Qualification, dated February 5, 1992.
On 10/09/07 the web page no longer exists.

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Reference Type: Report
Author: Aviation Flight Standards (AFS)-840
Year: 1997
Title: Qualification and approval of personal computer-based aviation training devices
Institution: Federal Aviation Administration (FAA)
Date: May 12
Type: FAA Advisory Circular

Report Number: AC 61-126
Number of Pages: 11
Abstract: This advisory circular (AC) provides information and guidance to potential training device manufacturers and aviation training consumers concerning a means, acceptable to the Administrator, by which personal computer-based aviation training devices (PCATD) may be qualified and approved for flight training toward satisfying the instrument rating training under the provisions of Title 14 of the Code of Federal Regulations (14 CFR) parts 61 and 141. While these guidelines are not mandatory, they are derived from extensive Federal Aviation Administration (FAA) and industry experience in determining compliance with the pertinent parts of 14 CFR. Mandatory terms used in this AC such as "shall" and "must" are used only in the sense of ensuring applicability of this method of compliance. PCATDs are distinct from flight training devices (FTD) qualified under AC 120-45, Airplane Flight Training Device Qualification, and flight simulators qualified under AC 120-40, Airplane Simulator Qualification. It also provides acceptable criteria under which the airplane of FTD flight-hour training time required for an instrument rating may be reduced by using PCATDs that have been determined to meet acceptable FAA standards. This AC details only one means of determining the acceptability of such devices for use in instrument training curricula.
Notes: Cancelled by AC 61-TD.
URL:
http://www.airweb.faa.gov/Regulatory_and_Guidance_Library/rgAdvisoryCircular.nsf/0/D0D8CDA61E05EB90862569BA0052B8F6?OpenDocument&Highlight=ac%2061-126

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Reference Type: Web Page
Author: Aviation Flight Standards (AFS)
Year: 1996
Title: CFR 14 Parts 1 through 199: Index of FARs
Access Year: 2006
Access Date: Sept. 6
Abstract: FAR PART 1--DEFINITIONS AND ABBREVIATIONS
FAR PART 11--GENERAL RULE-MAKING PROCEDURES
FAR PART 13--INVESTIGATIVE AND ENFORCEMENT PROCEDURES
FAR PART 14--RULES IMPLEMENTING THE EQUAL ACCESS TO JUSTICE ACT OF 1980
FAR PART 15--ADMINISTRATIVE CLAIMS UNDER FEDERAL TORT CLAIMS ACT
FAR PART 21--CERTIFICATION PROCEDURES FOR PRODUCTS AND FAR PARTS
FAR PART 23--AIRWORTHINESS STANDARDS: NORMAL, UTILITY, ACROBATIC, AND COMMUTER CATEGORY AIRPLANES
FAR PART 25--AIRWORTHINESS STANDARDS: TRANSPORT CATEGORY AIRPLANES
FAR PART 27--AIRWORTHINESS STANDARDS: NORMAL CATEGORY ROTORCRAFT
FAR PART 29--AIRWORTHINESS STANDARDS: TRANSPORT CATEGORY ROTORCRAFT
FAR PART 31--AIRWORTHINESS STANDARDS: MANNED FREE BALLOONS
FAR PART 33--AIRWORTHINESS STANDARDS: AIRCRAFT ENGINES
FAR PART 34--FUEL VENTING AND EXHAUST EMISSION REQUIREMENTS FOR TURBINE ENGINE POWERED AIRPLANES
FAR PART 35--AIRWORTHINESS STANDARDS: PROPELLERS
FAR PART 36--NOISE STANDARDS: AIRCRAFT TYPE AND AIRWORTHINESS CERTIFICATION
FAR PART 39--AIRWORTHINESS DIRECTIVES
FAR PART 43--MAINTENANCE, PREVENTIVE MAINTENANCE, REBUILDING, AND ALTERATION
FAR PART 45--IDENTIFICATION AND REGISTRATION MARKING
FAR PART 47--AIRCRAFT REGISTRATION
FAR PART 49--RECORDING OF AIRCRAFT TITLES AND SECURITY DOCUMENTS
FAR PART 61--CERTIFICATION: PILOTS AND FLIGHT INSTRUCTORS
FAR PART 63--CERTIFICATION: FLIGHT CREWMEMBERS OTHER THAN PILOTS
FAR PART 65--CERTIFICATION: AIRMEN OTHER THAN FLIGHT CREWMEMBERS
FAR PART 67--MEDICAL STANDARDS AND CERTIFICATION

FAR PART 71--DESIGNATION OF CLASS A, CLASS B, CLASS C, CLASS D, AND CLASS E AIRSPACE AREAS; AIRWAYS; ROUTES; AND REPORTING POINTS
FAR PART 73--SPECIAL USE AIRSPACE
FAR PART 77--OBJECTS AFFECTING NAVIGABLE AIRSPACE
FAR PART 91--GENERAL OPERATING AND FLIGHT RULES
FAR PART 93--SPECIAL AIR TRAFFIC RULES AND AIRPORT TRAFFIC PATTERNS
FAR PART 95--IFR ALTITUDES
FAR PART 97--STANDARD INSTRUMENT APPROACH PROCEDURES
FAR PART 99--SECURITY CONTROL OF AIR TRAFFIC
FAR PART 101--MOORED BALLOONS, KITES, UNMANNED ROCKETS AND UNMANNED FREE BALLOONS
FAR PART 103--ULTRALIGHT VEHICLES
FAR PART 105--PARACHUTE JUMPING
FAR PART 107--AIRPORT SECURITY
FAR PART 108--AIRPLANE OPERATOR SECURITY
FAR PART 109--INDIRECT AIR CARRIER SECURITY
FAR PART 119--CERTIFICATION: AIR CARRIERS AND COMMERCIAL OPERATORS
FAR PART 121--CERTIFICATION AND OPERATIONS: DOMESTIC, FLAG, AND SUPPLEMENTAL AIR CARRIERS AND COMMERCIAL OPERATORS OF LARGE AIRCRAFT
FAR PART 125--CERTIFICATION AND OPERATIONS: AIRPLANES HAVING A SEATING CAPACITY OF 20 OR MORE PASSENGERS OR A MAXIMUM PAYLOAD CAPACITY OF 6,000 POUNDS OR MORE
FAR PART 129--OPERATIONS: FOREIGN AIR CARRIERS AND FOREIGN OPERATORS OF U.S. REGISTERED AIRCRAFT ENGAGED IN COMMON CARRIAGE
FAR PART 133--ROTORCRAFT EXTERNAL-LOAD OPERATIONS
FAR PART 135--AIR TAXI OPERATORS AND COMMERCIAL OPERATORS
FAR PART 137--AGRICULTURAL AIRCRAFT OPERATIONS
FAR PART 139--CERTIFICATION AND OPERATIONS: LAND AIRPORTS SERVING CERTAIN AIR CARRIERS
FAR PART 141--PILOT SCHOOLS
FAR PART 142--TRAINING CENTERS
FAR PART 143--GROUND INSTRUCTORS
FAR PART 145--REPAIR STATIONS
FAR PART 147--AVIATION MAINTENANCE TECHNICIAN SCHOOLS
FAR PART 150--AIRPORT NOISE COMPATIBILITY PLANNING
FAR PART 151--FEDERAL AID TO AIRPORTS
FAR PART 152--AIRPORT AID PROGRAM
FAR PART 155--RELEASE OF AIRPORT PROPERTY FROM SURPLUS PROPERTY DISPOSAL RESTRICTIONS
FAR PART 156--STATE BLOCK GRANT PILOT PROGRAM
FAR PART 157--NOTICE OF CONSTRUCTION, ALTERATION, ACTIVATION, AND DEACTIVATION OF AIRPORTS
FAR PART 158--PASSENGER FACILITY CHARGES (PFC'S)
FAR PART 161--NOTICE AND APPROVAL OF AIRPORT NOISE AND ACCESS RESTRICTIONS
FAR PART 169--EXPENDITURE OF FEDERAL FUNDS FOR NONMILITARY AIRPORTS OR AIR NAVIGATION FACILITIES THEREON
FAR PART 170--ESTABLISHMENT AND DISCONTINUANCE CRITERIA FOR AIR TRAFFIC CONTROL SERVICES AND NAVIGATIONAL FACILITIES
FAR PART 171--NON-FEDERAL NAVIGATION FACILITIES
FAR PART 183--REPRESENTATIVES OF THE ADMINISTRATOR
FAR PART 185--TESTIMONY BY EMPLOYEES AND PRODUCTION OF RECORDS IN LEGAL PROCEEDINGS, AND SERVICE OF LEGAL PROCESS AND PLEADINGS
FAR PART 187--FEES
FAR PART 189--USE OF FEDERAL AVIATION ADMINISTRATION COMMUNICATIONS SYSTEM
FAR PART 191--WITHHOLDING SECURITY INFORMATION FROM DISCLOSURE UNDER THE AIR TRANSPORTATION SECURITY ACT OF 1974

FAR PART 198--AVIATION INSURANCE
URL: http://ecfr.gpoaccess.gov/cgi/t/text/text-idx?&c=ecfr&tpl=/ecfrbrowse/Title14/14tab_02.tpl

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Reference Type: Report
Author: Aviation Flight Standards (AFS)
Year: 1998
Title: Airline transport pilot and aircraft type rating practical test standards for helicopter
City: Washington, DC
Institution: Federal Aviation Administration (FAA),
Date: August
Report Number: FAA-S-8081-20
URL: http://www.faa.gov/training_testing/testing/airmen/test_standards/pilot/media/FAA-S-8081-20.pdf

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Reference Type: Report
Author: Aviation Flight Standards (AFS)
Year: 1998
Title: Airline transport pilot and/or type rating: Practical test standards for airplane and helicopter
Series Editor: Federal Aviation Administration (FAA)
City: Washington, DC
Institution: United States Government Printing Office
Report Number: FAA-S-8081-5B
Author's Title and Affiliation: Flight Standards Service, Washington DC 20591
Notes: This version has been cancelled. See FAA-S-8081-5D and FFA-S-8081-20.

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Reference Type: Report
Author: Aviation Flight Standards (AFS)
Year: 2001
Title: Airline transport pilot and/or type rating practical test standards
Institution: Federal Aviation Administration (FAA)
Date: February
Report Number: FAA-S-8081-5D
Number of Pages: 9
Keywords: practical test standards (PTS)
Abstract: Title 14 of the Code of Federal Regulations (14 CFR) part 61 specifies the areas in which knowledge and skills must be demonstrated by the applicant before the issuance of an airline transport pilot certificate and/or a type rating in airplanes. The CFRs provide the flexibility to permit the FAA to publish practical test standards (PTSs) containing specific TASKS in which pilot competency must be demonstrated.
Notes: This version has been cancelled. See FAA-S-8081-5E.

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Reference Type: Web Page
Author: Aviation Flight Standards (AFS)
Year: 2006
Title: Flight standards advisory circular index
Access Year: 2006
Access Date: Sept. 6
Abstract: AC No: 20-62D
ELIGIBILITY, QUALITY, AND IDENTIFICATION OF AERONAUTICAL REPLACEMENT PART

This advisory circular (AC) provides information and guidance for use in determining the quality, eligibility, and traceability of aeronautical parts and materials intended for installation on U.S. certificated products and to enable compliance with the applicable regulations.
Special Issue AC No: 43-16
AFS-96-1, TRANSPORTATION OF OXYGEN GENERATORS (CHEMICAL)
The purpose of the special issue is to advise and provide guidance concerning the prohibition of transporting chemical oxygen generators as cargo on passenger-carrying aircraft.
AC No: 61-101
PRESOLO WRITTEN TEST
To provide guidance to flight instructors in developing a written test to administer to student pilots prior to solo flight.
AC: 61-103
ANNOUNCEMENT OF AVAILABILITY: INDUSTRY-DEVELOPED TRANSITION TRAINING GUIDELINES FOR HIGH PERFORMANCE AIRCRAFT.
This advisory circular (AC) informs all Federal Aviation Administration (FAA) certificated pilots and flight instructors of the availability of industry-developed guidelines for pilots transitioning into high performance single and multiengine piston-powered small airplanes and single and multiengine turbopropeller small airplanes.
AC No: 61-107
OPERATIONS OF AIRCRAFT AT ALTITUDES ABOVE 25,000 FEET MSL AND/OR MACH NUMBERS (M sub mo) GREATER THAN .75
This advisory circular (AC) is issued to alert pilots transitioning to complex, high-performance aircraft which are capable of operating at high altitudes and high airspeeds of the need to be knowledgeable of the special physiological and aerodynamic considerations involved within this realm of operation.
AC No. 61-10A
REFRESHER COURSES FOR PRIVATE AND COMMERCIAL PILOTS
Interest of pilots in refresher courses and special training to upgrade their piloting skills is increasing significantly. Training courses are being held at "pilot clinics" sponsored by state aeronautics commissions and national aviation organizations, and by local agencies such as flying clubs and operators organizations. The number of pilots who are individually seeking advanced flight training is also increasing.
AC No. 61-12M
STUDENT PILOT GUIDE
The Federal Aviation Administration (FAA) is charged by Congress with the promotion, encouragement, and development of civil aeronautics. This guide seeks to encourage the development of civil aviation by providing guidance to novice pilots.
AC No: 60-22
AERONAUTICAL DECISION MAKING
This Advisory Circular (AC) provides introductory material, background information, and reference material on Aeronautical Decision Making (ADM). The material in this AC provides a systematic approach to risk assessment and stress management in aviation, illustrates how personal attitudes can influence decision making and how those attitudes can be modified
AC No: 61-65C
CERTIFICATION: PILOTS AND FLIGHT INSTRUCTORS
This advisory circular (AC) provides guidance for pilots and flight instructors on the certification standards, written test procedures, and other requirements contained in Federal Aviation Regulations (FAR) Part 61.
AC No: 61-67B
STALL AND SPIN AWARENESS TRAINING
This advisory circular (AC) explains the stall and spin awareness training required under Part 61 of the Federal Aviation Regulations (FAR) and offers
guidance to flight instructors who provide that training.
AC No: 61-83C
NATIONALLY SCHEDULED FEDERAL AVIATION ADMINISTRATION- APPROVED, INDUSTRY-CONDUCTED FLIGHT INSTRUCTOR CLINICS
This advisory circular (AC) provides guidance for the preparation and approval of a training course outline (TCO) for industry-conducted flight instructor

refresher clinics (FIRC), and sets forth guidelines to assist qualified sponsors/ organizations in obtaining approval for the use of a designated airman certification representative (ACR) employed solely by the FIRC sponsor.
AC No: 61-84B
ROLE OF PREFLIGHT PREPARATION
This advisory circular (AC) modifies and updates the flight information available to pilots as a result of changes in the basic Airmen Information Manual format.
AC No: 61-89D
PILOT CERTIFICATES: AIRCRAFT TYPE RATINGS
This Advisory Circular (AC) provides a generic type rating curriculum that may serve as a basis for schools to develop a training course outline (TCO) to
meet the type rating training requirements of the Federal Aviation Regulations (FAR) Parts 61 and 141.
AC No: 61-98A
CURRENCY AND ADDITIONAL QUALIFICATION REQUIREMENTS FOR CERTIFICATED PILOTS
This advisory circular (AC) provides information for certificated pilots and flight instructors to use in complying with the flight review required by Federal Aviation Regulations (FAR) Section 61.56, the recent flight experience requirements of FAR Section 61.57, and the general limitations contained in FAR Section 61.31(d), (e), and (g).
AC No: 90-23E
AIRCRAFT WAKE TURBULENCE
This advisory circular (AC) is intended to alert pilots to the hazards of aircraft wake turbulence and recommends related operational procedures.
AC No: 90-42F
TRAFFIC ADVISORY PRACTICES AT AIRPORTS WITHOUT OPERATING CONTROL TOWERS
This advisory circular (AC) contains good operating practices and procedures for use when approaching or departing airports without an operating control tower and airports that have control towers operating part time. This AC has been updated to include changes in radio frequencies and phraseology.
AC No: 90-66A
RECOMMENDED STANDARD TRAFFIC PATTERNS AND PRACTICES FOR AERONAUTICAL OPERATIONS AT AIRPORTS WITHOUT OPERATING CONTROL TOWERS
This advisory circular (AC) calls attention to regulatory requirements and recommended procedures for aeronautical operations at airports without operating control towers. It recommends traffic patterns and operational procedures for aircraft, lighter than air, glider, parachute, rotorcraft, and ultralight vehicle operations where such use is not in conflict with existing procedures in effect at those airports.
AC No: 90-89A
ULTRALIGHT FLIGHT TESTING HANDBOOK
This advisory circular (AC) sets forth suggestions and safety related recommendations to assist amateur and ultralight builders in developing individualized aircraft flight test plans.
AC No: 91.21-1
USE OF PORTABLE ELECTRONIC DEVICES ABOARD AIRCRAFT
This advisory circular (AC) provides aircraft operators with information and guidance for assistance in the compliance of Federal Aviation Regulations (FAR) Section 91.21.
URL:
http://www.airweb.faa.gov/Regulatory_and_Guidance_Library/rgAdvisoryCircular.nsf/MainFrame?OpenFrameSet

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Reference Type: Report
Author: Aviation Flight Standards (AFS)
Year: 2008
Title: Airline transport pilot and type rating practical test standards
Institution: Federal Aviation Administration (FAA)
Date: August
Report Number: FAA-S-8081-5F
Notes: Replaces FAA-S-8081-5E (2006)
URL: http://www.faa.gov/training_testing/testing/airmen/test_standards/pilot/media/FAA-S-8081-5F%20Change%202%20Revised.pdf

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Reference Type: Electronic Article
Author: Aviation Safety Council (ASC)
Year: 2000
Title: United's near miss sparks pilot review
Periodical Title: ASC Newsletter
Issue: December
Keywords: upset recovery training (URT), United Airlines flight 863
Abstract: As the United Airlines jumbo jet lifted off from San Francisco International Airport one night last summer (1998), one of its four engines lost power. Because of poor flying techniques, the co-pilot who was at the controls slowed and nearly stalled and crashed the plane.
URL: http://www.asc.gov.tw/author_files/e3.pdf

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Reference Type: Web Page
Author: Aviation Safety Network
Year: 2003
Title: Aircraft accident description McDonnell Douglas DC-10-40F N141WE - San Salvadore International Airport
Series Editor: Flight Safety Foundation
Series Title: Aviation Safety Network
Access Year: 2006
Access Date: October 19
Last Update Date: August 22, 2003
Keywords: upset recovery training (URT), McDonnell Douglass DC-10-40F accident
Abstract: At rotation, the flightcrew heard a sound described as a 'thump' or 'bang'. After becoming airborne, hydraulic pressure was lost on the nos. 1 and 2 systems. The flightcrew lowered the landing gear and returned to a landing on the takeoff runway. The airplane was brought to a stop and shut down. Examination found extensive damage in the left wing, above the left main landing gear, that included fractured nos. 1 and 2 hydraulic lines, and fractured or damaged mechanical control cables, pulleys, push rods, and electrical wiring. The no. 5 tire was found blown, and tread on the no. 1 tire damaged, both on the left main mount. Marks of a reverser cascade, identified as coming from a Boeing 727 engine, were found impressed into the runway, and a cascade was recovered in a search of the takeoff runway. Pieces of what appeared to be aluminum and other aircraft debris were also found on and near the takeoff runway.

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Reference Type: Web Page
Author: Aviation Safety Network
Year: 2006
Title: Aircraft accident description McDonnell Douglas DC-9-15RC N565PC - Cleveland-Hopkins Airport
Series Editor: Flight Safety Foundation

Series Title: Aviation Safety Network
Access Year: 2006
Access Date: October 19
Keywords: McDonnell Douglas DC-9-15RC accident, compressor stall, upset recovery training (URT)
Abstract: Ryan Flight 590 landed at Cleveland at 23:44 and taxied to the mail ramp. Snow (dry and blowing) fell throughout the 35 minutes that the DC-9 was on the ground. The deicing service was not requested during this period. Clearance to taxi to runway 23 was received at 00:09. Takeoff clearance was given at 00:18.
The aircraft stalled during take-off and rolled 90 at 50-100 feet. The airplane then suffered compressor stalls, the left wing contacted the runway and the aircraft cart wheeled. The DC-9 came to rest inverted 6500 feet from the threshold.
URL: http://aviation-safety.net/database/record.php?id=19910217-2&lang=en

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Reference Type: Web Page
Author: Aviation Safety Network
Year: 2006
Title: Aircraft accident description McDonnell Douglass DC-9-32 EC-BYH - Granada Airport
Series Editor: Flight Safety Foundation
Series Title: Aviation Safety Network
Access Year: 2006
Access Date: October 19
Keywords: McDonnell Douglas DC-9-32 accident, blown tires, upset recovery training (URT)
Abstract: The DC-9 landed hard on runway 09, 50m past the threshold with 11 knots tailwind. The aircraft bounced and landed 360m further on after manual spoiler deployment. All the tires blew out and the fuselage broke in two between Stat & 760.
A vertical acceleration of 4.49g on the first impact and 4.79g on the second impact were recorded.
Notes: On 6/21/07, the web page was no longer available.
URL: http://aviation-safety.net/record.php?id=19920330-1&lang=en

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Reference Type: Web Page
Author: Aviation Safety Network
Year: 2007
Title: Aircraft accident description Boeing 737-4Y0 G-OBME - Kegworth
Series Editor: Flight Safety Foundation
Series Title: Aviation Safety Network
Access Year: 2006
Access Date: October 19
Last Update Date: April 27, 2007
Keywords: Boeing 737-4Y0 accident, compressor stalls, upset recovery training (URT)
Abstract: Flight 092 took off from London at 19:52 for a flight to Belfast. Some 13 minutes later, while climbing through FL283, moderate to severe vibration was felt, accompanied by a smell of fire in the cockpit. The outer panel of one of the no. 1 engine fan blades detached, causing compressor stalls and airframe shuddering. Believing the No. 2 engine had been damaged the crew throttled it back. The shuddering stopped and the No 2 engine was shut down. The crew then decided to divert to East Midlands. The flight was cleared for a runway 27 approach. At 900 feet, 2.4nm from the runway, no. 1 engine power suddenly decreased. As the speed fell below 125 knots, the stick shaker activated and the aircraft struck trees at a speed of 115 knots. The aircraft continued and impacted the western carriageway of the M1 motorway 10m lower and came to rest against the wooded embankment, 900m short of the runway.

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Reference Type: Electronic Article
Author: AVweb
Title: USAir 427: One accident, three views
Periodical Title: AVweb
Keywords: upset recovery training (URT), USAir 427, wake turbulence
Abstract: On September 8, 1994, USAir Flight 427, a Boeing 737-300 on a scheduled flight from Chicago to Pittsburgh, crashed while maneuvering to land at Pittsburgh International Airport. The airplane was destroyed by impact forces and all 132 persons on board were fatally injured. Three years of investigation has failed to yield conclusive proof of why the aircraft crashed. What is known is that the aircraft encountered wake turbulence from a preceding aircraft while at 6,000 feet and 190 knots. The effects of the wake should have been easily recoverable. However, a few seconds after encountering the wake vortex, the 737's rudder deflected full-left and remained in that position for 23 seconds until the aircraft impacted the ground in a near-vertical position.
In 1997, the National Transportation Safety Board asked major participants in the investigation to submit their findings and recommendations. The Air Line Pilots Association (ALPA), The Boeing Company, and US Airways all submitted lengthy reports, the full text of which are available here. We were fascinated by the diversity of findings among these three parties, and present summaries of all three here (with links to the full reports).
URL: http://www.avweb.com/other/us427vue.html
Access Date: April 6, 2007

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Reference Type: Conference Paper
Author: Baarspul, M.; Hosman, R. J.; Van der Vaart, J. C.
Year: 1986
Title: Some fundamentals of simulator cockpit motion generation
Conference Name: Advances in Flight Simulation: Visual and Motion Systems
Conference Location: London
Publisher: Royal Aeronautical Society (RAeS)
Date: April 20-May 1
Number of Pages: 20
Keywords: problem areas of aircraft simulator motion generation, motion simulation, false motion cues, disturbance cues, confidence cues, onset, transient and sustained cues, simulation time-delays
Abstract: After showing a few examples of motion hardware quality assessment, the present paper highlights some problem areas of aircraft simulator motion generation. Since motion simulation is, by nature, an engineering compromise, motion simulation errors (false motion cues) have to be accepted.
A qualitative framework, featuring disturbance cues, confidence cues and false cues on the one side and onset, transient and sustained cues on the other, is proposed and some examples of false transient cues due to motion filtering will be considered in the light of recent man machine research at Delft University of Technology. Special attention is given to proper phasing of motion cues and the role of simulation time-delays in connection with measured human operator time-delays.

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Reference Type: Report
Author: Baarspul, M.; Mulder, J. A.
Year: 1989
Title: Essays on stability and control
City: Delft, The Netherlands
Institution: Delft University of Technology
Report Number: Report LR-600

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Reference Type: Conference Paper
Author: Bachelder, E.; McRuer, D.; Hansman, R. J.
Year: 2002
Title: Experimental study of 3-D synthetic cues on rotorcraft hover performance
Conference Name: AIAA Atmospheric Flight Mechanics Conference
Conference Location: Monterey, CA
Publisher: American Institute of Aeronautics and Astronautics (AIAA)
Date: August 5-8
Electronic Resource Number: AIAA 2002-4873
Author's Title and Affiliation: Edward Bachelder and Duane McRuer: Systems Technology, Inc., Hawthorne, CA
R.J. Hansman: Massachusetts Institute of Technology
Number of Pages: 15
Keywords: night vision devices (NVD), synthetic cues, cueing, rotorcraft, helicopter, hover
Abstract: Helicopter flight using night vision devices (NVDs) is difficult to perform, as evidenced by the high accident rate associated with NVD flight compared to day operation. The approach proposed in this paper is to augment the NVD image with synthetic cueing, whereby the cues would emulate position and motion and appear to be actually occurring in the physical space on which they are overlaid. Synthetic cues allow for selective enhancement of perceptual state gains to match the task requirements.
A hover cue set was developed on an analogue of a physical target used in a flight handling qualities tracking task, a perceptual task analysis for hover, and fundamentals of human spatial perception. The display was implemented on a simulation environment, constructed using a virtual reality device, an ultrasound head-tracker, and a fixed-base helicopter simulator. Seven highly trained helicopter pilots were used as experimental subjects and tasked to maintain hover in the presence of aircraft position

disturbances while viewing a synthesized NVD environment and the experimental hover cues. The simulation employed a number of unique techniques that enabled identification of visual perception and division-of-attention effects. Measures of hover performance and subjective ratings were collected, and frequency analysis was used to measure system (i.e. pilot/display/vehicle suite) stability and bandwidth. Significant performance improvements in NVD flight were observed when using synthetic cue augmentation. Subjective ratings showed longitudinal control to be more difficult than in the other axes for both single and multi-axis control. This paper demonstrates that artificial magnification of perceptual states through synthetic cueing can be an effective method of improving night-vision helicopter hover operations.

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Reference Type: Conference Paper
Author: Bailey, Randall E.; Knotts, Louis H.; Horowitz, Scott J.; Malone, Hugh L.
Year: 1987
Title: Effect of time delay on manual flight control and flying qualities during in-flight and ground-based simulation
Conference Name: AIAA Flight Simulation Technologies Conference
Conference Location: Monterey, CA
Publisher: American Institute of Aeronautics and Astronautics (AIAA)
Date: August 17-19
Electronic Resource Number: AIAA Paper No. 87-2370
Author's Title and Affiliation: Bailey and Knotts: Calspan Advanced Technology Center, Buffalo, NY Capt. Horowitz and Capt. Malone: USAF, Human Resources Laboratory, Williams AFB, AZ
Number of Pages: 9
Keywords: time delay, pilot-induced oscillations (PIO), flying qualities
Abstract: (from introduction) During the flight testing of the F-16, F-18, Tornado, and Space Shuttle vehicles, potentially disastrous pilot-induced oscillations (PIO) were encountered. These severe flying qualities deficiencies were largely attributed to the delay between cockpit control input and aircraft response introduced by the flight control systems. These incidents spurred considerable research investigating the effects of time delay on flying qualities.

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Reference Type: Journal Article
Author: Baillie, S. W.
Year: 1992
Title: Handling qualities research at the Flight Research Laboratory, IAR/NRC, 1980-1990 and beyond
Journal: Canadian Aeronautics and Space Journal
Volume: 38
Issue: 1
Pages: 9-15
Date: March
Author's Title and Affiliation: Flight Research Laboratory, IAR/NRC, Ottawa, Ontario, Canada
Number of Pages: 7
Keywords: flight research laboratory, IAR airborne simulator, rotorcraft, handling qualities requirements, useable cue environment, vertical axis, side arm controller
Abstract: A summary of the handling qualities research performed at the Flight Research Laboratory, Institute for Aerospace Research/National Research Council Canada (IRC/NRC) over the past 10 years is presented. Three major areas are discussed: the study of advanced military rotorcraft handling qualities requirements, the integration and development of 4-axis side-arm controllers for rotorcraft, and investigations regarding the expansion of rotorcraft IFR operations.

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Reference Type: Conference Paper
Author: Baillie, Stewart W.; Hui, Ken; DeLeeuw, Jaap
Year: 1992
Title: The flight test and data analysis program for the development of a Boeing/De Havilland Dash 8 simulator model
Conference Name: Flight Mechanics Symposium
Conference Location: Chania, Crete, Greece
Publisher: Advisory Panel for Aerospace Research and Development
Date: May 11-14
Author's Title and Affiliation: Baillie, Hui: Flight Research Lab, IAR/NRC, Montreal Road, Ottawa, Ontario K1A 0R6, Canada
DeLeeuw: Ph.D., AERCOL
Number of Pages: 19
Keywords: flight tests, flight control, performance evaluation, integrated systems, test procedures, avionics, digital systems
Abstract: A joint program between CAE Electronics Ltd. Montreal, and Flight Research Laboratory, NRC, was conducted to develop high fidelity simulator models of Dash 8 Series 100 and 300 aircraft. This paper focuses primarily on the Series 100 program. The flight test portion of the program entailed a relatively limited set of instrumentation due to aircraft ownership and regulatory constraints. The primary measurements were the basic inertial quantities and flight path reconstruction techniques were used to generate the time histories of other required flight path parameters (such as angle of attack and sideslip). The major problem of flight test data was analyzed using Maximum Likelihood Estimation with reliance on trim condition data for initial model estimates. The final simulator model was validated using specifically designed maneuvers conducted solely for validation purposes.
Notes: Published in October 1992.

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Reference Type: Journal Article
Author: Ball, Karlene; Sekuler, Robert
Year: 1980
Title: Models of stimulus uncertainty in motion perception
Journal: Psychological Review
Volume: 87
Pages: 435-469
Number of Pages: 35
Abstract: A model is proposed to account for the loss in visibility of moving targets that occurs when an observer is uncertain about the target's direction of motion. The model's key features are an array of directionally selective visual mechanisms and a rule governing the mechanisms from which an observer will derive sensory data. In response to uncertainty about two possible directions of motion, the observer is assumed to use a mechanism whose peak sensitivity is to a direction midway between the two possible directions. Seven experiments, using both reaction time and forced-choice data, demonstrate the predictive advantages of this midway model over competing single-band and multiple-band models. Additionally, the experiments reveal several new properties of human motion perception: (a) direction and velocity information have orthogonal representations in the visual system; (b) although motion sensitivity does not vary with direction, the prediction with which small changes in direction can be recognized does, reflecting differential breadth of tuning for directionally selective mechanisms sensitive to various directions; and (c) motion-analyzing mechanisms are broadly tuned for direction as well as speed.
Notes: Referenced in Ruud Hosman's book, *Pilot's perception and control of aircraft motions* (1996).

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Reference Type: Conference Paper
Author: Baret, Michel
Year: 1978
Title: Six degrees of freedom large motion system for flight simulators

Conference Name: Flight Mechanics Panel Specialists' Meeting on Piloted Aircraft Environment Simulation Techniques
Conference Location: Brussels, Belgium
Publisher: Advisory Group for Aerospace Research and Development (AGARD)
Date: April 24-27
Author's Title and Affiliation: Le Matériel Téléphonique, Division Simulateurs et Systèmes Electroniques, 3 avenue Albert Einstein, 78192 Trappes Cedex, France
Number of Pages: 8
Keywords: six degrees of freedom, long-stroke, hydrostatic bearings, hollow-rod jack
Abstract: The special feature of the six degrees of freedom large motion system described in this document is the long-stroke, hollow-rod jack with hydrostatic bearings.
This technique provides an improved performance and considerably reduces the level of the unwanted accelerations normally generated by motion systems, while offering new possibilities in the study of control laws.

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Reference Type: Report
Author: Barhydt, Richard; Adams, Catherine A.
Year: 2006
Title: Human factors considerations for area navigation departure and arrival procedures
Pages: 1-10
Report Number: L-19296, NASA/TM-2006-214531
Author's Title and Affiliation: NASA Langley Research Center
Keywords: area navigation, terminal procedures, human factors, flight operations
Abstract: Area navigation (RNAV) procedures are being implemented in the United States and around the world as part of a transition to a performance-based navigation system. These procedures are providing significant benefits and have also caused some human factors issues to emerge. Under sponsorship from the Federal Aviation Administration (FAA), the National Aeronautics and Space Administration (NASA) has undertaken a project to document RNAV-related human factors issues and propose areas for further consideration. The component focusing on RNAV Departure and Arrival Procedures involved discussions with expert users, a literature review, and a focused review of the NASA Aviation Safety Reporting System (ASRS) database. Issues were found to include aspects of air traffic control and airline procedures, aircraft systems, and procedure design. Major findings suggest the need for specific instrument procedure design guidelines that consider the effects of human performance. Ongoing industry and government activities to address air-ground communication terminology, design improvements, and chart database commonality are strongly encouraged. A review of factors contributing to RNAV in-service errors would likely lead to improved system design and operational performance.

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Reference Type: Edited Book
Editor: Barlow, H. B.; Mollon, J. D.
Year: 1982
Title: The senses
City: Cambridge, UK
Publisher: Cambridge University Press

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Reference Type: Conference Paper
Author: Barnes, A. G.
Year: 1978
Title: Simulating the visual approach and landing
Conference Name: Flight Mechanics Panel Specialists' Meeting on Piloted Aircraft Environment Simulation Techniques

Conference Location: Brussels, Belgium
Publisher: Advisory Group for Aerospace Research and Development (AGARD)
Date: April 24-27
Author's Title and Affiliation: Chief Simulation Engineer, British Aerospace, Aircraft Group, Warton Division, Warton Aerodrome, Lancashire, PR4 1AX, United Kingdom
Number of Pages: 13
Keywords: visual approach, landing, textural quality
Abstract: A general view is taken of the standards of simulation which are currently achieved in training and research simulators. The approach and landing is subdivided into separate phases; straight-in approach, curved approach, flare and ground roll. The piloting task is critically examined in each case with particular reference to the use of outside world visual cues. The merits and deficiencies of existing simulators, as a means of providing the equivalent information, are then discussed. Improvements to the overall simulation of the landing approach are more likely to emerge if a better understanding of the information which the pilot uses in each phase is available. This paper is an attempt to assemble some of the information pieces, and to relate them to the technology of simulation.

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Reference Type: Conference Paper
Author: Barnes, A. G.
Year: 1985
Title: Simulation of aircraft behavior on and close to the ground
Conference Name: Flight Mechanics Panel Symposium on Flight Simulation
Conference Location: Cambridge, United Kingdom
Publisher: Advisory Group for Aerospace Research and Development (AGARD)
Date: September 30 - October 3
Author's Title and Affiliation: British Aerospace plc, Warton Division, Preston, Lancs PR4 1AX, United Kingdom
Number of Pages: 4
Keywords: behavior, ground simulation
Abstract: (from 2. Contents) The first part of the report lists the benefits to be reaped from a good simulation of ground handling. They are considerable. They apply not only to Research and Development, but to Pilot Training. They apply to Military Aircraft of every type, and to Civil Aircraft of every type. In fact, we confined ourselves to fixed-wing aircraft; there is an equal case to be made for a report on the status of simulation of helicopters, on and close to the ground. [...] The report next considers the components which are needed to put together a simulation - the data set, the computer, the visual system, the motion system, and other cueing devices. [...] The report then strongly recommends the use of a motion system for landing and take-off simulation. [...] Examples are quoted of various programs, to demonstrate the effectiveness of simulators. Both Research and Training applications are presented. They illustrate that many operators have for many years made good use of simulators in this phase of flight, for a wide variety of problems. Even so, simulator improvements now offer much greater possibilities.
Notes: Published in September 1986.

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Reference Type: Journal Article
Author: Baron, Sheldon; Levison, William H.
Year: 1977
Title: Display analysis with optimal control model of the human operator
Journal: Human Factors
Volume: 19
Issue: 5
Pages: 437-457
Date: October
Author's Title and Affiliation: Bolt Beranek and Newman Inc., Cambridge, MA

Number of Pages: 21
Keywords: optimal control model
Abstract: Application of the optimal control model of the human operator to problems in display analysis is discussed. Those aspects of the model pertaining to the operator-display interface and to operator processing are reviewed and discussed. The techniques are then applied to the analysis of advanced display/control systems for a Terminal Configured Vehicle. Model results are compared with those obtained in a large, fixed-based simulation.

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Reference Type: Government Document
Author: Barr, Ann Calvaresi
Year: 2009
Title: Challenges in implementing performance-based navigation in the US air transportation system
Department: US Department of Transportation
Pages: 1-11
Author's Title and Affiliation: Ann Calvaresi Barr, Principal Assistant Inspector General for Auditing and Evaluation
Number of Pages: 11
Notes: Presentation before the Committee on Transportation and Infrastructure, Subcommittee on Aviation, US House of Representatives

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Reference Type: Journal Article
Author: Barrett, Gerald V.; Cabe, Patrick A.; Thornton, Carl L.; Kerber, Harold E.
Year: 1969
Title: Evaluation of a motion simulator not requiring cockpit motion
Journal: Human Factors
Volume: 11
Issue: 3
Pages: 239-244
Date: June
Author's Title and Affiliation: Gerald V. Barrett, Management Research Center, University of Rochester
Patrick A. Cabe, Carl L. Thornton, and Harold Kerber, Goodyear Aerospace Corporation
Number of Pages: 5
Abstract: A new type of system for simulating motion cues employs a seat made up of six differentially inflatable sections. This device was evaluated with a sample of eight pilots in a cockpit mock-up. Seat motion significantly increased rated realism for a series of six maneuvers. When subjects were presented with motion cues while their eyes were closed, correct identification of maneuvers averaged 85% and rated confidence in judgments averaged 76%. The seat was considered to be a relatively simple, low-cost method for simulating motion cues.

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Reference Type: Journal Article
Author: Barrett, G. V.; Thornton, C. L.
Year: 1968
Title: Relationship between perceptual style and simulator sickness
Journal: Journal of Applied Psychology
Volume: 52
Issue: 4
Pages: 304-308
Author's Title and Affiliation: Goodyear Aerospace Corporation, Akron, Ohio
Number of Pages: 5
Keywords: simulator sickness, perceptual style, cue conflict
Abstract: Simulator sickness was hypothesized to be caused by the conflict between the visual presentation of apparent motion and the lack of any corresponding body sensation of motion. The

hypothesis was tested by correlating individual differences in scores on the Rod and Frame Test (RFT; which measures accuracy of adjustment of a rod to true vertical under conditions of visual-kinesthetic conflict) and degree of simulator sickness. The data for Series 3 of the RFT and the indexes of sickness were best represented by hyperbolic functions yielding correlations of .40-.52. Implications for simulation technology and for a general conflict of cue theory are discussed with emphasis on supporting evidence from several areas of investigation.

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Reference Type: Conference Paper
Author: Bartel, Charles; Foster, Dan
Year: 2004
Title: Life cycle motion base cost comparison: Electric vs. hydraulic
Conference Name: SimTecT 2004: Simulation - Better Than Reality?
Conference Location: Canberra, Australia
Publisher: Simulation Industry Association of Australia (SIAA)
Date: May 24-27
Author's Title and Affiliation: Bartel: Simulation Marketing Manager, Industrial Controls Division, Moog Inc.
Foster: Engineering Manager, Industrial Controls Division, Moog Inc.
Number of Pages: 6
Abstract: Until very recently, motion systems for flight training have been hydraulically actuated. Today these systems are being provided using electric actuation technology.
This paper was developed to provide information for potential users of motion simulators in navigating the question of electric or hydraulic actuation. The focus of this paper is the life cycle cost associated with the motive technology used in motion simulators. The life cycle of a motion base can be divided into four phases and an estimate of total ownership must include the cost from each phase:
1) capital procurement
2) installation
3) operation
4) maintenance
A detailed comparison of the two technologies, the limitations, and differences as they apply to motion systems is included. Estimates of actual costs are used to calculate the net savings and break even point between the two technologies.
URL: www.siaa.asn.au/get/2396672252.pdf

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Reference Type: Newspaper Article
Reporter: Bates, Karl Leif
Year: 1995
Title: Seasick in cyberspace
Newspaper: The Detroit News
Issue Date: December 11
Number of Pages: 3
Keywords: cybersickness, virtual reality
Abstract: Your sense of balance is aided by a structure called the semicircular canals in the inner ear which works just like a carpenter's level, measuring tilt in six directions.
Disagreement between what the semicircular canals report and what your eyes see is one source of discomfort for virtual reality users.
Notes: As of 2/02/07, the web page was no longer available
URL: http://detnews.com/menu/stories/28102.htm

Reference Type: Conference Paper
Author: Baughn, James; Wolf, Jason
Year: 1998
Title: Teaching aircraft flight performance in aeronautical engineering using PC-based flight simulation
Conference Name: AIAA/SAE World Aviation Conference
Conference Location: Anaheim, CA
Publisher: American Institute of Aeronautics and Astronautics (AIAA); Society of Automotive Engineers (SAE)
Date: September 28-30
Electronic Resource Number: AIAA-1998-5530
Number of Pages: 7
Keywords: PC-based flight simulation, Personal Computer-based Aviation Training Device (PCATD), Microsoft Flight Simulator, teaching flight performance, aeronautical engineering students
Abstract: This paper describes some ways in which PC-based flight simulation can be used to teach aircraft flight performance and flight testing to aeronautical engineering students. Two PC-based flight stimulation programs are used here for this purpose; the Jeppesen FS200 PCATD and Microsoft Flight Simulator 98. Examples of student flight test assignments using these programs are given for cruise (straight and level, unaccelerated) flight, climbs, descents (power off glide), and for (level) maneuvering flight. Simulation flight test data from these assignments are presented and compared to theory. It is concluded that PC-based flight simulation can be a valuable tool for illustrating flight performance and flight testing to aeronautical engineering students and can be challenging, interesting and fun for students.

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Reference Type: Electronic Article
Author: BBC News
Year: 2006
Title: Air traffic simulator introduced
Periodical Title: BBC News
Volume: 2007
Issue: Feb. 5
Pages: Online News article
Abstract: Air traffic control staff will use a £1.5m simulator to train to use a £50m control tower at Heathrow.
URL: http://news.bbc.co.uk/2/hi/uk_news/4975974.stm
Access Date: May 5, 2006

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Reference Type: Journal Article
Author: Beaubien, J. Matthew; Baker, David P.; Salvaggio, Amy Nicole
Year: 2004
Title: Improving the construct validity of line operational simulation ratings: Lessons learned from the assessment center
Journal: The International Journal of Aviation Psychology
Volume: 14
Issue: 1
Pages: 1-17
Date: February
Number of Pages: 17
URL: http://www.airteams.org/publications/team_training-aviation/imprving_const_validity.pdf

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Reference Type: Magazine Article
Author: Beaudan, Eric
Year: 1991
Title: Flight simulation in the 90's
Magazine: Aviation and Aerospace
Volume: 64
Issue Number: 6
Pages: 18-20
Date: June
Number of Pages: 3
Abstract: Flight simulation, a $4 billion industry worldwide, is moving into the 1990s at an aggressive pace. With the introduction of such new aircraft as the Airbus A330/340, the Advanced Tactical Fighter, the C-17 airlifter and the US Army's LH light helicopter, the commercial and military market for simulators is growing at the rate of 20 per cent a year. The leading manufacturers of flight simulators--Canada's CAE Electronics Ltd. and its Link subsidiary in the US, Hughes Training and Support System Group and its British subsidiary Rediffusion, British Aerospace's Reflectone Inc., France's Thomson-CSF, and FlightSafety International of the U.S.--are capitalizing on this trend by introducing technology that will make flight simulation more realistic and affordable.

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Reference Type: Conference Proceedings
Author: Becerra-Vargus, Mauricio; Belo, Eduardo M.; Grant, Peter R.
Year of Conference: 2009
Title: Robust control of a flight simulator motion base
Conference Name: AIAA Modeling and Simulation Technologies Conference
Conference Location: Chicago, IL
Publisher: American Institute of Aeronautics and Astronautics (AIAA)
Date: Aug. 10-13
Electronic Resource Number: AIAA-2009-5921
Author's Title and Affiliation: Becerra-Vargas: PhD Candidate, Department of Mechanical Engineering, Engineering School of Sao Carlos, University of Sao Paulo, Sao Paulo, Brazil
Belo: Titular Professor, Department of Mechanical Engineering, Engineering School of Sao Carlos, University of Sao Paulo, Sao Paulo, Brazil
Grant: Associate Professor, Institute for Aerospace Studies, University of Toronto, Toronto, Ontario, Canada
Number of Pages: 13
Keywords: inverse dynamic control
Abstract: The purpose of this study is to apply inverse dynamics control for a six degree of freedom flight simulator motion system. Imperfect compensation of the inverse dynamic control is intentionally introduced in order to simplify the implementation of this approach. Two control strategies are applied in the outer loop of the inverse dynamic control to counteract the effects of imperfect compensation. The first one is designed using Laypunov stability theory (LST) and the second one is designed using H1 theory. Forward and inverse kinematics and full dynamic model of six degrees of freedom motion base driven by electromechanical actuators are briefly presented. Describing function, dynamic threshold and some maneuvers computed from the washout filter were used to evaluate the performance of the controllers.

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Reference Type: Journal Article
Author: Bekey, George A.; Burnham, Gerald O.; Seo, Jinbom
Year: 1977
Title: Control theoretic models of human drivers in car following
Journal: Human Factors
Volume: 19

Issue: 4
Pages: 399-413
Date: August
Author's Title and Affiliation: Bekey: University of Southern California, Los Angeles, CA
Burnham: Jet Propulsion Laboratory, Pasadena, CA
Seo: Korean Institute of Science and Technology, Seoul, Korea
Number of Pages: 15
Abstract: This paper is concerned with mathematical models of the control behavior of human drivers while following another vehicle in single lane traffic. The emphasis is on the representation of the individual driver, rather than on such abstract parameters of multi-lane traffic as average density or average velocity. Three basic types of approaches to representing the driver's control strategy are reviewed. First is a classical control structure in which assumptions concerning the stimulus-response characteristics of the driver are included, and a form for his control strategy algorithm is assumed. The second class of models is based on optimal control theory. The major feature of this class of models is that an assumed performance index is explicitly included in the formulation, so that the driver's control strategy arises as a result of his attempts to minimize this index or criterion. The third class of models reviewed in the paper are heuristic models, which arise from control theory. The first of these, termed the "look-ahead" model, is based on the assumption that the driver is capable of observing more than one car ahead of him, and that he adjusts his own strategy from an analysis of the behavior of a majority of the vehicles he perceives. The second of these heuristic models is a finite state structure which is developed from the hypothesis that the driver attempts at all times to maintain a velocity equal to that of the lead car along with a safe headway. The paper concludes with a brief discussion of some current areas of research and possible applications.

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Reference Type: Journal Article
Author: Bellenkes, A; Bason, R; Yacavone, M
Year: 1992
Title: Spatial disorientation in naval aviation mishaps: A review of Class A incidents from 1980 through 1989
Journal: Aviation, Space, and Environmental Medicine (ASEM)
Volume: 63
Pages: 128-131
Date: February
Type of Article: Technical Note
Abstract: Spatial Disorientation (SD) has long been a major aeromedical factor contributing to naval aviation mishaps. In the past, it has been viewed as a generalized phenomenon, described by its vertigo-related symptoms. More recently, however, three distinct types of SD have been identified, each based on whether the aviator recognizes and responds to its onset. In the current retrospective study, Flight Surgeon and Mishap Investigation Report narratives from 33 Class A mishaps occurring from 1980 through 1989 were reviewed. SD was determined to have been a causal factor in all cases. The mishaps were examined to categorize SD into the three descriptive types and to describe the relationship (if any) between SD and various mission-related factors. Aircraft type, phase of flight, time of day, pilot experience, and flight topography were all considered. The results indicate that Types I and II SD could be identified as causal factors in all 33 Class A mishaps. Further, most Type I SD was experienced primarily by helicopter pilots at night while most Type II SD incidents affected let pilots during day missions.

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Reference Type: Conference Paper
Author: Benson, A. J.
Year: 1987
Title: Aetiological factors in simulator sickness

Conference Name: Aerospace Medical Panel Symposium on Motion Cues in Flight Simulation and Simulator Induced Sickness
Conference Location: Brussels, Belgium
Publisher: Advisory Group for Aerospace Research and Development (AGARD)
Date: September 29
Author's Title and Affiliation: Royal Air Force Institute of Aviation Medicine, Farnborough Hants GU14 6SZ, United Kingdom
Number of Pages: 8
Keywords: aetiological factors, motion sickness, visual display, cues, neural mismatch, simulator sickness
Abstract: The clinical features of simulator sickness are similar to the malaise induced by other motion stimuli. The essential aetiology of the condition is considered to be the same as in other types of motion sickness, namely, the mismatch between the motion information provided by the body's sense organs and the brain's internal model of 'expected' motion cues. The mismatch can be between concomitant inputs provided by the angular and linear acceleration transducers of the vestibular apparatus, or between visual and vestibular inputs. More significantly, in a fixed base simulator, it is the essence of 'expected' inertial cues when the ambient visual system is stimulated by the external world, visual display that engenders neural mismatch. Even when the simulator has a motion base, quantitative and temporal disparities between visual and inertial cues commonly occur and can contribute, along with visual distortions and other anomalies, to the induction of the motion sickness syndrome.
URL: http://stinet.dtic.mil/oai/oai?verb=getRecord&metadataPrefix=html&identifier=ADA202492

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Reference Type: Book Section
Author: Benson, A. J.
Year: 1988
Title: Spatial disorientation - Common illusions
Editor: Dhenin, Geoffrey
Book Title: Aviation Medicine: Physiology and Human Factors
City: London
Publisher: Tr-Med
Pages: 434-467
Chapter: 21
Keywords: spatial disorientation, illusions, upset recovery training (URT)
Abstract: The aetiology of spatial disorientation is discussed in general terms in Chapter 20 [Benson, "Spatial Orientation"]. The salient features of some of the more frequently reported illusions, together with their causal mechanisms are the subject of this chapter.

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Reference Type: Journal Article
Author: Benson, A. J.; Spencer, M. B.; Stott, J. R.
Year: 1986
Title: Thresholds for the detection of the direction of whole-body, linear movement in the horizontal plane
Journal: Aviation, Space, and Environmental Medicine (ASEM)
Volume: 57
Issue: November
Pages: 1088-1096
Date: November
Author's Title and Affiliation: Royal Air Force Institute of Aviation Medicine, Farnborough, Hampshire, U.K.
Number of Pages: 9
Keywords: translational threshold, whole-body motion
Abstract: Thresholds for the detection (at p=0.67 correct) of the direction of discrete linear movements in the horizontal plane, having a cosine bell velocity trajectory and duration of 3 s, were determined in 24

subjects. Thresholds in the Z body axis (mean 0.154 m/s^2) were significantly higher than thresholds for movement in the X (mean 0.063 m/s^2) and Y (mean 0.057 m/s^2) body axes. In 8 subjects, X axis acceleration threshold was found to increase as a monotonic function of stimulus duration over the range of 0.98 to 6.96 s and exhibited similar frequency-dependent characteristics to thresholds for the detection of continuous oscillatory stimuli. This finding implies that the sensory system mediating the transduction and perception of liminal, whole-body linear movement is sensitive to a combination of the acceleration and rate change of acceleration (jerk) of the motion stimulus, and has similar dynamics to the "irregular" sensory receptors of the otolith organs.

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Reference Type: Journal Article
Author: Benson, Johan
Year: 1998
Title: Conversations with Richard Christiansen
Journal: Aerospace America
Volume: May
Pages: 14-16
Date: May
Number of Pages: 3
Abstract: Richard Christiansen is acting associate administrator for NASA's Aeronautics and Space Transportation Technology Enterprise. He was formerly the director of the aerospace research division, leading NASA's efforts in implementing basic aeronautics research. This includes flight demonstration projects on advanced concepts for rotocraft, high-speed research, high-performance aircraft, hypersonic vehicles, and advanced space transportation systems.
He began his NASA career at the Ames Research Center, Moffett Field, Calif., and has been instrumental in many of the enterprise's successes in aerospace research and development.
Christiansen received a B.S. degree in aerospace engineering from the California Polytechnic State University in Pomona in 1979 and an M.S. degree in aerospace engineering from Stanford University in 1985.

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Reference Type: Report
Author: Berger, Daniel R.; Schulte-Pelkum, Jörg; Bülthoff, H.
Year: 2007
Title: Simulating believable forward accelerations on a Stewart motion platform
City: Tübingen, Germany
Institution: Max Planck Institute for Biological Cybernetics
Report Number: Technical Report No. 159
Author's Title and Affiliation: Department Bülthoff (Cognitive and Computational Psychophysics), Max Planck Institute for Biological Cybernetics, Tübingen, Germany
Keywords: motion simulation, forward accelerations, Stewart platform motion, hexapod platform motion
Abstract: Here we present a study where human participants rated the believability of forward accelerations simulated with a hexapod motion platform equipped with a projection screen. Visual forward accelerations were presented together with brief forward surge translations and backwards pitches of the platform, and synchronous random up-down movements of the camera in the visual scene and the platform. The magnitudes of all the parameters were varied independently across trials. Even though we found a high variability between participants, most believable simulation occurred with strong visual accelerations combined with backwards pitches of the platform which approximately matched the visually simulated acceleration. This was contrary to a previous study, which had found most believable simulation when the platform movements simulated a much smaller acceleration than what was shown visually. Furthermore, surge translations increased believability if they qualitatively matched the magnitude of visual acceleration. The acceleration-deceleration profile of the surge translation and the magnitude and frequency range of the up-down movements had little effect on the believability. When strong visual acceleration cues were given, most participants reported trials as realistic even when the

platform tilt rate was above thresholds for the vestibular canals reported in literature. These results can be used to optimize motion cueing algorithms for the simulation of linear accelerations in motion simulators.
URL: http://www.kyb.mpg.de/publications/attachments/mpik-tr-159_4373[0].pdf
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Reference Type: Conference Proceedings
Author: Berger, Daniel R.; Terzibas, Cengiz; Beykirch, Karl; Bülthoff, Heinrich H.
Year of Conference: 2007
Title: The role of visual cues and whole-body rotation in helicopter hovering control
Conference Name: AIAA Modeling and Simulation Technologies Conference
Conference Location: Hilton Head, SC
Publisher: American Institute of Aeronautics and Astronautics (AIAA)
Date: August 20-23
Electronic Resource Number: AIAA 2007-6798
Author's Title and Affiliation: Berger: Research Scientist, Max Planck Institute for Biological Cybernetics, P.O. Box 2169, 72012 Tübingen, Germany
Terzibas: Research Assistant, Max Planck Institute for Biological Cybernetics, P.O. Box 2169, 72012 Tübingen, Germany
Beykirch: Research Scientist, Max Planck Institute for Biological Cybernetics, P.O. Box 2169, 72012 Tübingen, Germany
Bülthoff: Professor, Max Planck Institute for Biological Cybernetics, P.O. Box 2169, 72012 Tübingen, Germany
Abstract: Helicopters in flight are unstable, and hovering at one spot requires the pilot to do a considerable amount of active control. To date, it is still under discussion which sensory cues helicopter pilots use for this stabilization task, and how these cues are combined. Here we investigated how cues from different sensory modalities (visual cues and body cues) are used when humans stabilize a simulated helicopter at a target location in a closed perception-action loop. Participants were seated inside a closed cabin on a Stewart platform equipped with a projection screen. They had to stabilize a simulated helicopter on a target spot. To investigate the influence of individual visual cues on the stabilization, a minimalistic visual scene was used. Two spheres in the scene represented the location of the target and the position of the helicopter. Optical flow was provided by world-stationary random dots, and a horizon was produced by a black ground plane and white sky. We measured stabilization performance in ten different conditions: black background, horizon, optical flow, both horizon and optical flow, and horizontal stripes; all of these both with and without platform rotation cueing. Physical pitch and roll body rotations were presented by tilting the platform exactly as the simulated helicopter tilted.
Our results show that all manipulated cues – horizon, optical flow, and platform rotations – can help the participants to stabilize a simulated helicopter. In particular, adding physical rotation cues to visual stimulation in a simulator can significantly improve the ability of trained participants to stabilize the simulated helicopter at a target location.
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heinrich.buelthoff@tuebingen.mpg.de

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Reference Type: Conference Paper
Author: Bergeron, H. P.
Year: 1980
Title: The effects of motion cues on compensatory tracking tasks
Conference Name: AIAA Visual and Motion Simulation Technology Conference

Conference Location: Cape Canaveral, FL
Publisher: American Institute of Aeronautics and Astronautics (AIAA)
Date: March 18
Electronic Resource Number: AIAA-1970-352
Keywords: motion cues, tracking
Abstract: The data presented are taken from tests which were designed to define areas where motion cues are beneficial in controlling compensatory tracking tasks and to determine some of the requirements of these motion inputs. One- and two-axis tests were made with and without motion. Two-axis tests were also performed in which the amplitude of motion, as compared to the visual input, was varied from one run to the next. The results indicate that the addition of motion had little or no effect on the control of the single-axis tasks. However, motion did make a difference in the more difficult two-axis tasks. Also, the data show that a reduction in the scale of motion, in the two-axis tasks, to as little as one-fourth motion scale, produces results comparable to when full scale motion was used.

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Reference Type: Newspaper Article
Reporter: Berggren, Selina Mård ; Källgren, Laban
Year: 2006
Title: Special feature: Introducing a method for enabling comparison of research results between vehicle simulators
Newspaper: Test and Evaluation Technical Group (TETG) Newsletter
Issue Date: Fall
Author's Title and Affiliation: Berggren: Human, Vehicle, Transport System Interaction, Swedish National Road and Transport Research Institute
Källgren: Vehicle Technology and Simulation, Swedish National Road and Transport Research Institute
Abstract: Applying an interdisciplinary approach, this paper proposes a method that enables comparison of research results between platforms of different levels of fidelity. Technological and software development over the last decades has given the research society new, complex tools for studying and understanding the interaction between human and vehicle transport systems. Today's vehicle simulators range from low fidelity to extremely high fidelity. Simulator studies involving several partners make it possible to learn about cultural differences in driving behavior, to share costs, to include a large number of study subjects, to generalize results and to increase research exchange. However, there are methodological problems in comparing data obtained in studies involving several different vehicle simulators. Differences in simulator complexity and fidelity give rise to uncertainty in the analysis of data. As collaboration worldwide increases it is evident that it is crucial to develop a tool for comparison of research results between vehicle simulators.
URL: http://www.engineering.uiowa.edu/simusers/Readings/pdf/SEP2006_TETG_NewsletterB.pdf

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Reference Type: Report
Author: Beringer, Dennis B.
Year: 1996
Title: Use of off-the-shelf PC-based flight simulators for aviation human factors research
Date: April
Type: Technical Report
Report Number: DOT/FAA/AM-96/15
Author's Title and Affiliation: Civil Aeromedical Institute, Federal Aviation Administration, Oklahoma City, OK 73125
Number of Pages: 16
Keywords: personal computer-based aviation flight simulation, simulator research, instrument flight psychology, applied psychology
Abstract: Flight simulation has historically been an expensive proposition, particularly if out-of-window views were desired. Advances in computer technology have allowed a modular, off-the-self flight simulation (based on 80486 processors or Pentiums) to be assembled that has been adapted, with

minimal modification, for conducting general aviation research. This simulation includes variable flight instrumentation, forward, 45 and 90 degree left external world views, and a map display. Control inputs are provided by high-fidelity analog controls (e.g., damped and self-centering yoke, high-performance throttle quadrant, gear, flap, and trim controls; and navigation radio frequency select). The simulation is based upon two commercially available flight simulation software packages, one originally designed as an instrument flight trainer and the other as a "game"-type flight simulation. The provisions of these packages are discussed highlighting their particular research capabilities, as well as their limitations. The comparatively low cost and ease of assembly/integration allow multiple "standardized" systems to be distributed for cooperative inter-laboratory studies. The approach appears to have utility for both research and training.

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Reference Type: Journal Article
Author: Beringer, Dennis B.; Ball, Jerry D.
Year: 2009
Title: Unknown-attitude recoveries using conventional and terrain-depicting attitude indicators: difference testing, equivalence testing, and equivalent level of safety
Journal: The International Journal of Aviation Psychology
Volume: 19
Issue: 1
Pages: 76-97
Date: January
Author's Title and Affiliation: FAA Civil Aerospace Medical Institute (CAMI)
Number of Pages: 23
Abstract: The objectives of this study were to assess the effects of differing formats of forward-looking primary flight display (PFD; electronic attitude-direction indicator, full-color terrain, uniformly brown terrain) on general aviation (GA) pilot recoveries from unknown attitudes and to determine if recovery assistance embodied in the display could be useful. Total recovery times and control reversals were examined as indexes
of performance for 40 GA pilots, and the recovery times were subjected to a comparative analysis using both a parametric difference analysis and an equivalence testing technique. Results suggest that for the specific conditions investigated, terrain- depicting PFDs supported performance that was equivalent to that observed with the standard attitude indicator. Equivalence testing is recommended for cases where it is desirable to determine if one device or system provides for performance that is equivalent to another.

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Reference Type: Journal Article
Author: Beringer, Dennis B.; Williges, Robert C.; Roscoe, Stanley N.
Year: 1975
Title: The transition of experienced pilots to a frequency-separated aircraft attitude display
Journal: Human Factors
Volume: 17
Issue: 4
Pages: 401-414
Author's Title and Affiliation: University of Illinois at Urbana-Champaign
Number of Pages: 14
Keywords: human factors engineering, display systems, horizontal indicators, flight testing, performance (human), pilots, tracking, horizontal orientation, flight simulators, naval training
Abstract: Independent groups of eight professional pilots each were given one flight in a Link GAT-2 simulator and one flight in a Beechcraft C-45H using, respectively, the moving horizon, moving airplane, and frequency-separated attitude displays. The flight tasks performed by the subjects included recovery from unknown attitudes, disturbed attitude tracking, and completion of an area navigation course. Data collected in the C-45H aircraft demonstrated superior performance of both the frequency-separated and moving horizontal displays when compared to the moving airplane display during unknown attitude recoveries. The frequency-separated display was superior to all others during disturbed attitude tracking.

It was concluded that the flight performance of experienced pilots during their initial transition to a frequency-separated flight attitude presentation is at least comparable, and for some tasks superior, to their flight performance with the conventional moving horizon presentation.

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Reference Type: Journal Article
Author: Berry, D. T.
Year: 1982
Title: Flying qualities: A costly lapse in flight control design?
Journal: Astronautics and Aeronautics
Pages: 54-57
Date: April
Author's Title and Affiliation: NASA Ames Research Center, Dryden Flight Research Facility
Number of Pages: 4
Abstract: Serious problems in flight control emphasize the need for timely and adequate research on flying qualities and in-flight simulation.

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Reference Type: Map
Cartographer: Bertin, R.J.V; Guillot, A.; Vienne, F. ; Graf, W. ; Collet, C. ; Espie, S.
Title: Objective measurement of simulator sickness and the role of visual-vestibular conflict situations: a study with vestibular-loss (a-reflexive) subjects
Short Title: Objective measurement of simulator sickness and the role of visual-vestibular conflict situations: a study with vestibular-loss (a-reflexive) subjects
Keywords: simulator sickness, motion sickness, visual vestibular conflict, vestibular loss
Abstract: Driving simulators are being used increasingly for research and development purposes as it is generally safer to evaluate new design or control principles in a mock-up situation. The fact that drivers can experience various and even extreme road conditions in a realistic and risk-free setting makes these simulators appealing also for education, training and even recreation. Progress in computer graphics and performance allow for highly realistic simulator visuals. High-end models are becoming somewhat better at generating acceptable inertial self-motion information, sometimes even providing real (but limited) linear translation in addition to angular movements. Simpler versions do not generate inertial information at all (fixed-base simulators). A problem that often occurs with all driving simulators is simulator sickness. This phenomenon closely resembles the classically experienced motion sickness and can make a user quit a simulator run within minutes — and cause him/her discomfort for up to several days.
QUESTIONS
It is commonly accepted that motion sickness is provoked by visual-vestibular conflict — is this true also for simulator sickness? If so, susceptibility in vestibular-loss patients should be significantly less than in controls, as it is for classical motion sickness. Can the phenomenon be quantified, better understood and ultimately predicted 'on line' through correlation of psychophysical subject reactions and simultaneously recorded neurovegetative activity? Specifically, is it possible to monitor simulator users and detect oncoming sickness before it becomes incapacitating?

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Reference Type: Conference Proceedings
Author: Beykirch, Karl; Nieuwenhuizen, F.M.; Teufel, H.J.; Nusseck, H.-G.; Butler, J.S.; Bülthoff, H.H.
Year of Conference: 2007
Title: Control of a lateral helicopter side-step maneuver in an anthropomorphic robot
Conference Name: AIAA Modeling and Simulation Technologies Conference and Exhibit
Conference Location: Hilton Head, SC
Publisher: American Institute of Aeronautics and Astronautics
Date: August 20-23
Electronic Resource Number: AIAA 2007-6801

Author's Title and Affiliation: Beykirch: Research Scientist
Nieuwenhuizen: Ph.D. student
Teufel: Research Assistant
Nussedk: VR-System Administrator
Butler: Research Scientist
Bülthoff: Professor
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Abstract: Our society relies more and more on flight simulation for pilot training to enhance safety and reduce costs. But to meet the highest level of general technical requirements for simulators set forth by the FAA and EASA requires high-cost equipment. To make simulator use more accessible, reduced costs might be achieved with novel simulator designs and/or through research to improve the performance of existing designs. This report explores the use of such a novel design, based on an anthropomorphic robot arm to reproduce an experiment designed to evaluate flight simulator motion requirements for helicopter pilot training. Results compare promisingly well to those from a large, high-performance facility where the original work was performed.
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Reference Type: Presentation
Author: Bigarré, J.
Year: 2006
Title: Training & safety - It's time to question our beliefs!
Presentation Event: RAeS International Working Group meeting
Event Location: Toulouse, France
Publisher: ATR Training Centre
Date: September 20

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Reference Type: Magazine Article
Author: Birch, Stewart
Year: 2002
Title: CFM powers Airbus
Magazine: Aerospace Engineering
Pages: 9-10
Date: October
Number of Pages: 2
Abstract: Full-scale testing of an acoustically upgraded CFM56-5B with double annular compressor is now under way.

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Reference Type: Web Page
Author: Bles, Willem
Year: 2005
Title: Desdemona: Advanced disorientation trainer
Access Year: 2007
Access Date: Feb. 5
Author's Title and Affiliation: Dr. Willem Bles, TNO Human Factors
Keywords: Desdemona, disorientation training, upset recovery training (URT)

Abstract: Desdemona is a sophisticated demonstration, simulation and training facility specified by Toegepast Natuurwetenschappelijk Onderzoek (TNO) Human Factors and developed by AMST Systemtechnik (Austria). Desdemona is planned to be operational in 2003 at the TNO Human Factors facility in Soesterberg, the Netherlands, for basic and advanced disorientation training courses for the benefit of the Royal Netherlands Air Force (RNLAF).
URL: http://www.amst-germany.de/publics/desdemona_pub.htm
Author Address: Dr. Willem Bles, TNO Human Factors, P.O., Box 23 3769 ZG, Soesterberg, The Netherlands E-mail: bles@tm.tno.nl

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Reference Type: Magazine Article
Author: Bles, Willem; Wentink, Mark; Mayrhofer, Michael; de Graaf, Bernd
Year: 2007
Title: Revolutions and more
Magazine: Military Simulation & Training (MS&T)
Issue Number: 1
Pages: 24-25
Author's Title and Affiliation: Bles, Wentink, and de Graaf: TNO Human Factors, Soesterberg, The Netherlands
Mayrhofer: AMST Systemtechnik, Ranshofen, Austria
Keywords: high-g, spatial disorientation, Desdemona, upset recovery training (URT)
Abstract: Cost reduction, saving the environment, and crew safety will contribute to the notion that simulators will be used more and more for pilot training in the near future especially for high g and spatial disorientation training. [The authors] describe Desdemona, a revolutionary motion platform.
URL: http://mst.texterity.com/mst/2007-1/

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Reference Type: Report
Author: Blickensderfer, B.; Liu, D.; Hernandez, A.
Year: 2005
Title: Simulation-based training: Applying lessons learned in aviation to surface transportation modes
Institution: Embry Riddle Aeronautical University
Date: June 30
Author's Title and Affiliation: Embry Riddle Aeronautical University
Recipient's Title and Affiliation: Center for Advanced Transportation Systems Simulation (CATSS)
Abstract: Executive Summary
After reviewing the literature regarding simulation for aviation training and reviewing the literature on use of simulation in surface transportation, a number of lessons learned become apparent.
Lesson Learned 1: Simulation has been proven to be an effective educational and instructional tool. In tests of flight simulator training effectiveness, trainees develop knowledge and skills in simulated systems as well as they do in the actual systems (Hays, Jacobs, Prince, & Salas, 1992). The simulator is an excellent classroom, as the learner is able to make mistakes and learn from them (Duncan & Feterle, 2000). The instructor is allowed to focus on teaching and not operating the vehicle. Additionally, many simulators have the capability to collect performance measures during the training scenarios that can help assess competencies and deficiencies. Not as much research has occurred regarding the effectiveness of training via simulation in the surface transportation domain compared to the aviation field, yet considerable research support has appeared. It is likely that the results regarding simulator effectiveness for aviation training will generalize to the surface transportation domain, but simulation must be used wisely. Users should consider the competencies needed to perform the task and the capabilities of the simulator. Not all simulators are appropriate for training all competencies. Furthermore, not all competencies require simulation for effective training.
Lesson Learned 2: Simulators increase safety and reduce training costs. As noted in our review of the aviation literature, two main benefits of using simulation for training are increased safety during training and reduced training costs.

In terms of safety, using simulators for training enables individuals to practice in conditions that would be too dangerous to train in actual situations (for example, aircraft engine failures, accidents, and other emergencies). This is also true when training driving and will likely be a major benefit of using simulation in surface transportation training.

Regarding cost, aviation simulation saves aircraft fuel, aircraft maintenance costs, and keeps aircraft available for revenue producing activities. In the case of automobiles, buses, and trucks, although training via simulation would conserve fuel, the cost savings are most likely not as great as they are in aviation. Indeed, considerable driving training can occur in the actual vehicles at low cost. Training train operators, on the other hand, may benefit from significant cost savings as well as benefiting from the simpler logistics of training via simulators rather than actual trains.

A benefit related to both safety and cost is that simulation can be used to give trainees experiences with unusual events. Unusual events are just that—unusual. Despite their rare occurrences, they can prove deadly in aviation as well as in surface transportation. Simulation offers the opportunity for drivers to experience these and learn how to perform effectively in these unusual situations (Down, Petford, & McHale, 1982). Consider driver training. Driving around in the real world, the driver may not encounter many, if any, hazardous or emergency situations. Using simulation, the scenario can be scripted to include a variety of hazards and emergencies. Thus, not only will simulation training give driver trainees the opportunity to master the knowledge and skills necessary to perform effectively in hazardous situations, but also it will do so in a safe environment.

Lesson Learned 3: Simulation alone does not equal training. Simulation is a tool for trainers to use (Salas, Bowers, & Rhodenizer, 1998). Simply experiencing a simulated environment is not effective training (Salas et al., 1998). Simulation must be used in a thoughtful, well-planned manner that includes identification of training needs, proper design of scenarios, appropriate performance measurement, and feedback to the learner (Oser et al., 1999). The same principles apply in surface transportation as well (Uhr et al., 2003).

Lesson Learned 4: Simulation is one variable in the “big picture” of training effectiveness. Training effectiveness is a complex problem (Cannon-Bowers et al., 1995, Colquitt et al., 2000, Baldwin and Ford, 1998). Training method (e.g., use of simulation) is one variable involved. Numerous other variables also exist including trainee characteristics, work environment characteristics, and the transfer environment. Simulation training will not solve every training challenge for any domain.

Lesson Learned 5: The Scenario Based Training model (Oser et al., 1999) is one method to ensure simulation is used appropriately. Aviation training researchers advocate using the scenario based training model to use simulation effectively. While a few papers have appeared in the surface transportation training literature regarding effective use of simulation (Uhr et al. 2003; Nagata & Kuriyama, 1983; Walker & Bailey, 2002; Down et al. 1982), limited advice exists regarding use simulation effectively in this domain. Fortunately, the basic principles of the Oser et al (1999) model apply to surface transportation and, if advocated in the surface field, can help instructors to use driving simulator systems most effectively. The Oser et al. approach is based on basic principles of learning. This approach guides training designers to 1) identify the task/mission and the knowledge, skills, and abilities involved; 2) design scenarios to include events which allow the trainee to develop and practice the specific knowledge, skills, and abilities identified; 3) design performance measures to enable the trainer to assess performance; and 4) ensure specific feedback is given to the trainee.

Lesson Learned 6: Effective human performance measurement is crucial both for simulation validation and assessing skill development. As new simulators are developed, validation must occur. Validation should occur not only from the engineering/system performance standpoint but also from the human performance perspective (Hays & Singer, 1989). For example, when examining whether performance in a simulator equals performance in the real-world task, accurate, reliable human performance measures are essential to understand the human interactions with the system. Without such measures, it will be impossible to quantify training transfer. Both objective and subjective measurement approaches exist. Careful time and attention should be paid to developing and selecting the appropriate measures to ensure a well-rounded assessment of skills.

Lesson Learned 7: Simulation fidelity is an important concept that needs to be understood. Simulation fidelity is the degree to which a device can replicate the actual environment or how “real” the simulation appears and feels (Alessi, 1998; Gross et al., 1999). Simulation fidelity is composed of a number of dimensions including psychological and cognitive factors as well as the more obvious physical factors (e.g., visual, auditory, motion, etc.). Numerous researchers are devoted to studying fidelity issues regarding aviation training such as how to define fidelity, fidelity dimensions, measuring fidelity, and the relationship between fidelity and training effectiveness, yet questions still remain. In terms of surface transportation, limited study exists on the relationship between fidelity and performance in surface transportation tasks. For comparable skills (e.g., control vs. perceptual vs. decision making), it is expected the findings from fidelity research in aviation should generalize to surface transportation. However, surface transportation researchers should use these findings as a springboard for their own domain specific research.

Lesson Learned 8: The relationship between simulation fidelity and training effectiveness is not a positive, linear relationship. The simulation industry pushes for higher and higher levels of physical fidelity. Indeed, as simulation technology continues to evolve, simulations come ever closer to being exact replicas of the real world environment. At the current time, high fidelity translates as high financial cost, and many questions remain regarding the cost-benefit trade-offs of using high physical fidelity simulations for aviation training. Research indicates that high fidelity is not necessary to train certain skills (Jentsch & Bowers, 1998; Koonce & Bramble, 1998). In terms of surface vehicle driver training, training control tasks such as braking will require a high level of physical fidelity. On the other hand, it is likely that for other skills (e.g., risk assessment training), a lower level of physical will be adequate (Fisher et al., 2002). Thus, an expensive, high fidelity simulator is not always required to fulfill training needs. However, more research is needed to identify the exact relationship between fidelity and training effectiveness.

Lesson Learned 9: Motion fidelity is not always necessary. Motion fidelity is the extent to which a simulator replicates the motion cues actually felt during flight (Kaiser & Schroeder, 2003). In terms of aviation, motion appears to provide very little to training effectiveness (Garrison, 1985; Ray, 1996 [sic]). While it is likely that these results generalize to surface transportation to some degree, the knowledge and skills required for effective driving differ somewhat from aviation (e.g., consider driving a vehicle over bumpy terrain), and motion is likely needed to train certain skills. Thus, additional domain specific research is needed.

Lesson Learned 10: Establishing a standard classification system for different types of simulations can facilitate collaboration within the simulation industry. In aviation, levels of simulation are specifically defined with certifications and regulations regarding necessary fidelity for training certain skills (e.g., level A, level B, and level C). Using a classification system of this nature has provided industry and academia with common terminology to use in simulation design and evaluation (i.e., everyone is using the same terminology to refer to the same concepts). In comparing the current simulation work in aviation to that of surface transportation, aviation has specific standards, but a simulation classification schema is not apparent in the surface transportation industry.

Lesson Learned 11: Many opportunities to use simulation exist—be creative! The aviation industry has moved beyond using simulation only for pilot training to also using it to train air traffic controllers. In addition, simulations are helping to design airport layouts, assess traffic problems, and teach ground workers airport navigation. In surface transportation, researchers have begun to use simulation to assess road design (Godley et al., 1997). Indeed, use of simulation seems limited only by our imagination.

As is the case in aviation training, the surface simulation industry is facing great challenges and also opportunities to make the roads safer, more efficient and enjoyable. With the development of technology, many driving operations become easier and require less effort. Unfortunately, these same technologies can introduce new opportunities for human error. The simulation industry must stay abreast of technological advances to produce up-to-date, effective training in a cost efficient manner. Many of the questions we posed in this report cannot be answered in a simple sentence, nor will the answers occur overnight. Instead, continued, fundamental research remains the key to understanding the human interaction with the vehicle.

URL: http://www.catss.ucf.edu/projects/documents/reports/pdf/ProjectFR_AviationSurface.pdf

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Reference Type: Electronic Article
Author: Boeing
Year: 1998
Title: Aerodynamic principles of large-airplane upsets
Periodical Title: Aero Magazine
Volume: 03
Keywords: upset recovery training (URT)
Abstract: Loss of airplane control in flight is a leading cause of fatalities in the commercial aviation industry. A variety of reasons exist for airplane upsets, but none is statistically significant. Reducing the number of reasons for upsets is a continual training process, and eliminating one reason will not necessarily reduce the number of loss-of-control accidents and fatalities. Additionally, many reasons for upsets are associated with the environment, in which case avoidance is the best solution, but is not always possible. Therefore, pilots must have the necessary knowledge and skills to recover an upset airplane.
Aerodynamic principles of large, swept-wing commercial jet airplanes are similar among all manufacturers. In the interest of safety, and the desire to acknowledge the commonality in recovery techniques, this article was written jointly by Airbus, Boeing Commercial Airplane Group, and Douglas Products Division. The article focuses on Airbus and Boeing airplanes that do not have electronic flight controls, commonly known as fly-by-wire. However, when a fly-by-wire airplane is in a degraded control law (mode), the recovery techniques are appropriate. Additionally, certain conditions can upset any airplane and the basic principles of recognition and recovery still apply regardless of the flight control architecture.
Pilots can be exposed to an infinite number of slightly different situations. For this reason, it is not possible to develop specific recovery procedures for each. Operators should address procedural applications of techniques within their fleet structures. Pilots who are knowledgeable about aerodynamics and who possess the skills to apply basic emergency techniques can return an upset airplane to normal flight parameters. Airbus and Boeing are dedicating many resources and actively working with an industry team to develop an airplane upset recovery training aid. When it is completed we will make it available to our customers at no charge.
URL: http://www.boeing.com/commercial/aeromagazine/aero_03/fo/fo01/index.html
Access Date: 3/25/08

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Reference Type: Electronic Article
Author: Boeing
Year: 2002
Title: Vertical situation display for improved flight safety and reduced operating costs
Periodical Title: Aero Magazine
Volume: 03
Issue: 20
Keywords: vertical situation display, controlled flight into terrain (CFIT), upset recovery training (URT)
Abstract: Boeing has developed a vertical situation display to help prevent controlled flight into terrain and approach and landing accidents. In addition, the vertical situation display is designed to reduce airline operating costs by decreasing the number of missed approaches, tail strikes, and hard landings and by reducing vertical navigation training time.
URL: http://www.boeing.com/commercial/aeromagazine/aero_20/vsd_story.html

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Reference Type: Training Aid
Author: Boeing; Airbus; Flight Safety International (FSI)
Year: 2008
Title: Airplane upset recovery training aid revision 2
Secondary Author: Carbaugh, Captain Dave; Rockliff, Captain Larry; Vandel, Bob
Date: November

Original Publication: Airplane upset recovery training aid (Revision 1, 2004)
Author's Title and Affiliation: Carbaugh: The Boeing Company, Co-Chair Upset Recovery Industry Team
Rockliff: Airbus, Co-Chair Upset Recovery Industry Team
Vandel: Flight Safety Foundation, Co-chair Upset Recovery Industry Team
Keywords: upset recovery training (URT)
Abstract: Industry solutions for large swept-wing turbofan airplanes typically seating more than 100 passengers.
URL:
http://www.faa.gov/other_visit/aviation_industry/airline_operators/training/media/AP_UpsetRecovery_Book.pdf

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Reference Type: Thesis
Author: Boer, Erwin R.
Year: 1995
Title: Identification of time varying systems with applications to adaptive human control
Academic Department: Electrical Engineering and Computer Science
City: Chicago
University: University of Illinois
Thesis Type: Doctor of Philosophy
Author's Title and Affiliation: Ir. Twente University, Enschede, The Netherlands, 1990
Abstract: In pursuit to identify an adapting human operator, five contributions resulted: 1) the Recursive Delay-time Identifier (RDI) capable of tracking time varying delay simultaneously with linear model coefficients, 2) an identifiable discrete-time Look Ahead Predictive Error Correcting (LAPEC) Human Operator Model (HOM) for pursuit and preview tracking, 3) new insights in human operator adaptation to the time varying experimental parameters (EPs), i.e. preview length (PV), reference signal bandwidth (BW) and control plant cutoff frequency (COF), 4) a set of performance measures that break the standard root mean squared error up into a shape match and a time shift component, 5) a set of experimental human operator tracking data collected under a wide variety of static and time varying conditions.
Application of the RDI to the data obtained under time varying conditions produced new insights into human operator adaptation. Humans respond differently to increasing and decreasing experimental parameters; a hysteresis type response is observed. Detectability differences plus performance driven adaptation are thought to cause the observed hysteresis in the sense that the degree to which subjects perceive a gradual change in the experimental parameter settings depends on whether it forces them to alter control to maintain a constant performance level or not. They tend to act on a performance decreasing change more acutely than one that allows them to maintain similar strategy without being penalized by a performance drop. This means that a decrease in preview, an increase in track bandwidth and an increase in control plant lag are adapted to quickest. These results could not have been obtained without the availability of the RDI.
The RDI was compared and contrasted with the following four other delay time tracking methods on simulated and experimental data: segmented cross correlations, peak to peak delay time estimation, segmented recursive least squares, and the multiple model approach. In all cases, the RDI performed equally well or better.
The RDI is based on the extended Kalman filter plus the Rauch-Tung-Striebel optimal smoother. The human delay time is treated as a non-linear operator which under the constraint of differentiability of the input and output signals (i.e. bandlimited signals) can be identified recursively. Applicability is also constrained by the rate at which delay time changes. Differentiability is imposed because the input signal is interpolated with a bicubic interpolation scheme to obtain fractional delay time estimates. This constraint is weak in the sense that the RDI shows good performance on stochastic bandlimited data. A significant advantage of the RDI over other static delay time identification methods is the fact that the delay time estimated are not limited to integer multiples of the sampling interval. One of its strong points is that it estimates delay time based on data sampled at the maximum available sampling frequency while the linear model coefficients can be identified on a decimated version of the same data sets to eliminate discrete time identification problems associated with high sampling frequencies.

The bicubic interpolation scheme proved superior in estimating subsample magnitudes and slopes of the track when compared with the truncated Whittacker interpolation, the third order Taylor expansion, the bicubic interpolation method, the biquadruple method, linear interpolation and the second and third order polynomial interpolation methods.
LAPEC- HOM was developed to provide a classical control based intuitive framework in which all results could be explained. It characterizes manual pursuit and preview tracking and consists of the following functional components: 1) visual reference signal processing delay, 2) visual reference signal filter/predictor, 3) error signal processing in terms of three different feed back loops, 4) internal model of control plant, 5) internal processing delay, 7) internal model of the neuro-muscular dynamics and 8) colored execution noise. LAPEC- HOM bypasses the identifyability problems associated with Optimal Control Models (OCMs) and is more flexible than existing classical HOMs. The predictor/filter component is based on the finding that humans apply prediction during short preview and visual filtering during long preview. It is also shown that human's equalize the control plant's lag if sufficient preview is available thus suggesting in internal models of the control plant and neuromuscular dynamics. Sufficient preview is a function of the human's internal processing delay, the track bandwidth and the control plant dynamics.
The 2D preview tracking experiments were conducted with a fixed vertical drag velocity, which means that the subjects had no control over the perceived bandwidth of the track. Tracking was performed in a dark sound-proof room, whereby the six subjects sat comfortably on a chair 30 inches away from the 19 inch screen holding the springless joy stick manipulator in the dominant hand with the lower arm supported in the horizontal position. Stick movement, sampled at 60 Hz, was congruent with the lateral movement of the cross on the screen, which indicated the output of the control plant. The reference signal (track) was represented by a vertical curved line. Part of the experimental design consisted of developing methods to construct smoothly varying preview, track bandwidth and control plant dynamics. Twelve different settings of the EPs were used for statics experiments (PV=0,167,700ms, BW=1.0,0.5Hz, COF=0.75,2.5Hz) and twenty three combinations of one or two time varying EPs were selected for the time varying experiments (PV=0-700ms, BW@1.0-0.25Hz, COF=0.5- 2.5Hz).
To compare the findings with those in the literature, several batch analyses were performed on the static experiment data. A new performance measure (RMSSE) was introduced that is defined as the Root Mean Square (RMS) of the error (RMSE) between the plant output and a realization of the reference signal that is shifted by the lag (LAG) at which maximum correlation (XCOR) between the track and the plant output occurs. It is a true measure of the shape mismatch between the system input and output. Application of the RMSSE revealed that high bandwidth tracking (BW=l.0Hz) for zero and 167 ms preview caused a significant increase in RMSE when the plant's lag increases while RMSSE showed no significant change. The lag did increase significantly indicating that the observed increase in RMSE was mainly due to an increase lag between the track and the plant output. This means that a short preview provided the subjects with enough information to match the reference signal shape very well but were not able to null the tracking lag. Longer preview allowed for zero tracking delay for either COF setting.
The principal findings based on the batch analysis are: 1) regardless of the preview length, a 1.0 Hz track is never tracked as accurately as a 0.5 Hz one as indicated by the fact that all four measures (RMSE, RMSSE, LAG, XCOR) show a performance decrease for such a change in track bandwidth, 2) performance increased always when preview changed from 0 to 167 ms while a further increase to 700 ms caused a performance decrease in two of the less consistent subjects which was a result of anticipation as well as a decrease in shape match between the track and the control plant output while performance remained steady for the other four subjects and 3) a 167 ms preview provides enough look ahead time and information for further prediction to assure lag -free tracking except when the control plant introduces a significant lag; in that case, humans need more preview to equalize this lag (700 ms is sufficient). These findings were explained from the point of view that the HO acts as a predictor in his attempt to null his inherent delay time and equalize the control plant's lag.
The Fourier transform obtained bode plots showed good agreement with the identified ARMAX(2,2,2) model. Humans were found to induce substantially less noise when preview increased which is expected to be due to a better trade off between applying control and letting the tracking error temporarily increase. Furthermore, the cutoff frequencies associated with the AR portion of the model showed a dramatic decrease as preview increases resulting in a lower high frequencies gain which supports the finding that humans apply predictive tracking during low preview and visual filtering during high preview tracking.

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Reference Type: Edited Book
Editor: Boff, K.; Kaufman, L.; Thomas, J.
Year: 1986
Title: Handbook of perception and human performance
City: New York
Publisher: John Wiley and Sons
Volume: 1
Number of Volumes: 2
Edition: 1st
ISBN: 0-471-88544-4(v.1)

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Reference Type: Book Section
Author: Boldovici, J.A.
Year: 1987
Title: Measuring transfer in military settings
Book Title: Transfer of learning: Contemporary research and applications
Pages: 239-260
Number of Pages: 22

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Reference Type: Report
Author: Boldovici, John A.
Year: 1992
Title: Simulator motion
Date: September
Type: ARI technical report
Report Number: 961
Author's Title and Affiliation: U.S. Army Research Institute
Number of Pages: 37
Keywords: simulator motion, force motion cueing, test reliability, statistical power, testing unsafe tasks, validity of inferences
Abstract: This review analyzes the arguments for and against using various methods of force motion cueing in land-vehicle and aircraft simulators. Research literature was reviewed and opinions were solicited from 31 authorities, 24 of whom replied. Analysis of the literature and of the reasons given by the authorities for and against the use of force motion cueing indicated the following: 1) no transfer of training data support using motion-based rather than fixed-base simulators; 2) the absence of supporting data may be due to the unknown characteristics of motion used in transfer research, safety considerations that preclude conducting definitive transfer of training experiments, and deficiencies in experiments that lead to inadequate statistical power; and 3) objective examination of the effects of force motion cueing on transfer to land vehicles and aircraft requires developing and using reliable and safe tests for assessing the performance of tasks that cannot safely be performed in parent vehicles. In the absence of transfer data demonstrating the superiority of fixed-based or motion-based simulators, analyses to identify discriminative stimuli are recommended. The report presents algorithms for deciding for which tasks the use of force motion cueing in training is likely to facilitate transfer to parent vehicles and for deciding whether seat shakers, g-seats, or motion bases are sufficient to provide discriminative stimuli for task performance.

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Reference Type: Conference Paper
Author: Bolton, Martin J. P.
Year: 1978
Title: A high resolution visual system for the simulation of in-flight refueling
Conference Name: Flight Mechanics Panel Specialists' Meeting on Piloted Aircraft Environment Simulation Techniques
Conference Location: Brussels, Belgium
Publisher: Advisory Group for Aerospace Research and Development (AGARD)
Date: April 24-27
Author's Title and Affiliation: Research Engineer, Redifon Simulation Ltd., Gatwick Road, Crawley, West Sussex RH10 2RL, England
Number of Pages: 14
Keywords: simulation, in flight refueling
Abstract: This paper describes a unique visual system, developed for the simulation of the in-flight refueling task; it incorporates both wide bandwidth and computer generated image (CGI) techniques. After a brief review of the in-flight refueling task and the simulation requirements, Redifon's previous experience in this field is outlined and the overall design of the latest visual system is described. Particular attention is paid to the problem of providing the essential visual information within the constraints of cost and available technology. An important part of this visual system is the "special effects unit," which provides all video processing and image generation functions under the control of an autonomous computer.

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Reference Type: Conference Paper
Author: Boothe, Edward M.
Year: 1992
Title: A case for simulator motion standards
Conference Name: European Forum on Matching Technology to Training Requirements
Publisher: Royal Aeronautical Society (RAeS)
Date: May
Author's Title and Affiliation: Federal Aviation Administration, National Simulator Program, Atlanta, GA
Number of Pages: 9
Abstract: The Federal Aviation Administration, the Civil Aviation Authority of the United Kingdom, and other aviation authorities require that simulators used in pilot training and checking be equipped with a motion base. The purpose, of course, is to provide the needed onset cues during pilot licensing and performance assessment. There is data to support the concept that pilot performance is improved when motion cues are available versus pilot performance in fixed-based devices. Data that are available are often disputed. In fact, discussions intended to address standards and testing of simulator motion systems are usually terminated without conclusion. Such discussions seem to quickly degenerate into emotional arguments about the need or worth of motion at all. Opinion seems to be about 50 percent for and 50 percent against motion. Proponents of airborne or in-flight simulation, however, cite the adverse influence that lack of motion has on pilot performance as a justification for in-flight simulation. Likely, such arguments will continue. The regulatory authorities have, however, taken the conservative position of "motion required." It is important, therefore, to properly specify the motion system characteristics so as to provide the appropriate cues and minimize any false cues.

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Reference Type: Conference Paper
Author: Boothe, Edward M.
Year: 1992
Title: Simulation realism, cost and benefits
Conference Name: Information Technology Exposition and Conference (ITEC)
Date: April 8
Author's Title and Affiliation: Manager, Federal Aviation Administration, National Simulator Program

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Reference Type: Report
Author: Boothe, Edward M.
Year: 1993
Title: The requirement for high quality data for flight simulators
City: Stone Mountain, GA
Institution: Flight Simulation and Training
Date: May
Author's Title and Affiliation: Consultant, Flight Simulation and Training, Stone Mountain, GA
Number of Pages: 9
Abstract: There are several categories of data required for flight simulator modeling and validation including aerodynamic, flight control engine, aircraft systems, terrain and, of course, dimensional. Each is important, each contributes to the quality of simulation and none can be neglected. The Federal Aviation Administration (FAA) in the Advanced Simulation Plan, however, emphasized the aerodynamic data and reiterated the emphasis in Advisory Circular (AC) 120-40B. The new international standards published by The Royal Aeronautical Society also emphasize aerodynamic data. In fact, all except aerodynamic data are hardly mentioned in these documents or are simply required by inference in statements such as "a full scale replica of the airplane simulated" or "systems must simulate the applicable airplane systems operation." The International Air Transport Association design and performance data requirements reflect the same aerodynamic data importance. This emphasis has stimulated the acquisition of much higher quality data for simulator aerodynamic modeling and validation.
The emphasis on aerodynamic data and simulator validation is well justified based on the permitted use of flight simulators. Total pilot training and certification, requiring no additional training in an airplane, is permitted and has become common practice among airlines. This practice demands that a simulator provoke proper pilot responses which in turn demands a continuous mathematical model and quality data to describe the airplane and its systems.

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Reference Type: Appendix (Draft)
Author: Boothe, Edward M.
Year: 1996
Title: Appendix 7: Level B motion and aerodynamics tests requirements
Date: November 11
Number of Pages: 15
Notes: Appendix to FAA/Industry Symposium on Aeromodel Transcript, Bürki-Cohen (ed.) (1996). See http://www.volpe.dot.gov/opsad/pubs.html

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Reference Type: Report (Final)
Author: Borah, Joshua; Young, Laurence; Curry, Renwick
Year: 1978
Title: Sensory mechanism modeling
City: Ohio
Institution: Advanced Systems Division
Wright-Patterson Airforce Base

Date: October
Report Number: AFHRL-TR-78-83
Author's Title and Affiliation: Gulf + Western, Applied Science Laboratories, 335 Bear Hill Road, Waltham, MA 02154
Number of Pages: 85
Keywords: flight simulation, motion perception, orientation perception, optimal estimation, sensory system modeling, neural sensory receptors, vestibular sensors, tactile sensors, proprioceptive sensors, visual effects, motion effects, linearvection, circularvection
Abstract: Pilots use information from a variety of sensory mechanisms to determine their estimate of orientation and motion. An understanding of this process and quantitative model are essential for the development of effective simulator motion cueing devices. A multisensory model for dynamic spatial orientation is being developed for this purpose.

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Reference Type: Report (Interim)
Author: Borah, J.; Young, L. R.; Curry, R. E.
Year: 1977
Title: Sensory mechanism modeling
Institution: Air Force Human Systems Laboratory
Pages: 1-85
Date: February
Report Number: AFHRL-TR-77-70
Number of Pages: 86
Keywords: flight simulation, motion perception, orientation perception, optimal estimation, sensory system modeling, neural sensory receptors, vestibular sensors, tactile sensors, proprioceptive sensors, visual effects, motion effects, linearvection, circularvection
Abstract: Pilots use information from a variety of sensory mechanisms to determine their estimate of orientation and motion. An understanding of this process and a quantitative model are essential for development of effective simulator motion cueing devices. A multisensory model for dynamic spatial orientation is being developed for this purpose. Aircraft or simulator motion is translated into stimuli which are processed by dynamic models of the appropriate sensors (visual, vestibular, tactile, and proprioceptive), and are then fed to a central estimator which has been modeled as a linear optimal estimator, specifically a steady state Kalman Filter. In addition to the linear estimation process, some non-linear effects, such as the well documented delay in onset of visually induced motion, require non-linear additions to the model. Such additions have been kept to a minimum so as to retain the uniqueness and conceptual appeal of a linear optimization algorithm.
The model has been implemented as a computer program and has predicted some of the important qualitative characteristics of human dynamic spatial orientation under combined wide field visual motion and platform motion. Several types of special tactile and proprioceptive cues are also being considered but have not been validated.
The modeling effort has underscored the need for additional data in some areas and several experiments have been suggested to help fill these gaps.

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Reference Type: Journal Article
Author: Bos, J. E.; Bles, W.
Year: 1998
Title: Modeling motion sickness and subjective vertical mismatch detailed for vertical motions
Journal: Brain Research Bulletin
Volume: 47
Issue: 5
Pages: 537-542
Date: January 24
Number of Pages: 6

Abstract: In an attempt to predict the amount of motion sickness given any kind of motion stimulus, we describe a model using explicit knowledge of the vestibular system. First, the generally accepted conflict theory is restated in terms of a conflict between a vertical as perceived by the sense organs like the vestibular system and the subjective vertical as determined on the basis of previous experience. Second, this concept is integrated with optimal estimation theory by the use of an internal model. If detailed for vertical motions only, the model does predict typical observed motion sickness characteristics, irrespective the parameter setting. By adjusting the nonvestibular parameters, the model can also quantitatively be adapted to seasickness data from the literature. With this concept, sickness severity hypothetically can also be predicted for other motions, irrespective of their origin and complexity.

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Reference Type: Electronic Article
Author: Boser, Robert J.
Year: 2002
Title: What is the status of the solution to the B-737 rudder design defect? Is the problem solved?
Periodical Title: AirlineSafety.com
Author's Title and Affiliation: Editor-in-Chief, AirlineSafety.Com
Keywords: B737, rudder, upset recovery training (URT)
Abstract: [What is the status of the solution to the B-737 rudder design defect? Is the problem solved?] Yes, and no. Redesigned control units are being installed and pilots have been trained to "fly around" the problem in the interim. But, until they completely redesign the rudder so that it is controlled by at least two separate PCUs, like other airliners, I will not be satisfied the "fix" is sufficient to prevent any possible repetitions of previous incidents/accidents.
URL: http://www.airlinesafety.com/faq/B-737Rudder.htm
Access Date: October 17, 2006

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Reference Type: Conference Proceedings
Author: Bošković, Jovan D.; Redding, Joshua; Knoebel, Nathan
Year of Conference: 2009
Title: An adaptive fault management (AFM) system for resilient flight control
Conference Name: AIAA Guidance, Navigation, and Control Conference
Conference Location: Chicago, IL
Publisher: American Institute of Aeronautics and Astronautics (AIAA)
Pages: 1-19
Date: Aug. 10-13
Electronic Resource Number: AIAA-2009-6263
Author's Title and Affiliation: Bošković: Principal Research Engineer and Intelligent & Autonomous Control Systems Group Leader, Scientific Systems Company, Inc. (SSCI)
Redding: PhD Candidate, Massachusetts Institute of Technology (MIT) (on leave from SSCI)
Knoebel: Research Engineer, SSCI
Keywords: Fast on-Line Actuator Reconfiguration Enhancement (FLARE) System, self diagnostics (SD), adaptive fault management (AFM), resilient flight control, upset recovery training (URT)
Abstract: One of the major problems that arises in the context of upset prevention and recovery in flight control systems is the availability of the information about the new aircraft dynamics post-failure or post-damage. For that reason it is important to have an on-board system that will rapidly and accurately detect and identify a failure (or failures), or the location and extent of structural damage. However, such systems are commonly prone to false alarms. If false failure information is used in the feedback control law, this can lead to substantial performance deterioration and even instability of the closed-loop system. One possible solution to this problem is Self Diagnostics (SD) - a procedure where probing signals are injected into the system to try to identify failure or damage-related parameters. Such a procedure needs to be implemented with care since it can potentially excite aircraft structural modes. In addition, self diagnostics can induce an oscillatory response of the aircraft states while not still being insufficient to accurately identify the parameters, particularly if their number is large. Hence such an approach is effective only if

the number of failure-related parameters is small. Knowledge of the post-fault parameter values is important for: (i) calculation of available control authority immediately following an upset and control reconfiguration, (ii) computation of achievable trim points; and (iii) calculation of new control constraints. In this paper we present and discuss our Fast on-Line Actuator Reconfiguration Enhancement (FLARE) System that is based on decentralized detection and identification of flight control actuator failures, and results in a relatively small number of parameters that need to be identified on-line. FLARE was recently augmented by the self-diagnostics module, resulting in an effective system that accurately estimates the parameters such that the effect of the self diagnostic signals is not felt by the aircraft states. Hence the possibility of exciting the structural modes is minimized. The FLARE system with self diagnostics (FLARE-SD) is described in detail, as well as the areas where such knowledge can be effectively used to increase the pilot's awareness and improve flight safety. The features of the FLARE-SD system are illustrated through simulations of F/A-18 aircraft dynamics under actuator failures.
Notes: Research supported by NASA Langley Research Center.

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Reference Type: Report
Author: Bowen, Shane A.; Oakley, Brian P.; Barnett, John S.
Year: 2006
Title: Effects of motion on skill acquisition in future simulators
Institution: United States Army Research Institute for the Behavioral and Social Sciences
Pages: 1-24
Date: May
Report Number: 2006-07
Author's Title and Affiliation: Bowen and Oakley: Micro Analysis and Design, Inc.
Barnett: U.S. Army Research Institute
Number of Pages: 24
Keywords: training, motion-based simulation, human performance, simulator sickness
Abstract: In order to develop recommendations for the use of motion in ground vehicle simulators, a thorough literature review was conducted. Literature on motion cueing theories as well as basic and applied research in the use of motion in simulation was examined. A particular focus was paid to research on the effects of motion cueing on transfer of training from both ground vehicle and aircraft simulators. From the information gathered in the literature reviews on motion cueing, recommendations for the use of motion in ground vehicle training simulation were developed. In addition to motion cueing factors, theories and applied research on motion sickness were also investigated. As motion sickness holds the potential to significantly affect performance both in a simulator and in an actual ground vehicle, it was considered important to develop recommendations for the use of simulator motion to mitigate these effects. Guidelines were developed from the information gathered in this review for the use of simulator motion in training to diminish the effects of motion sickness.
Notes: Provides recommendations for ground, not air, vehicles

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Reference Type: Magazine Article
Author: Bradley, Perry
Year: 1996
Title: Advanced CRM: A trial program attempts to go a step further to help all pilots fly like the best pilots
Magazine: Business & Commercial Aviation
Pages: 62-66
Date: June
Number of Pages: 5
Keywords: CRM, ACRM, ACA, NTSB

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Reference Type: Report
Author: Bradshaw, Gary; Taylor, Henry; Lintern, Gavan; Talleur, Don
Year: 1999
Title: The potential of subjective estimates of transfer
Institution: Aviation Research Lab (ARL)
Date: May
Report Number: Technical Report ARL-99-6
Author's Title and Affiliation: Aviation Research Lab Institute of Aviation, University of Illinois at Urbana-Champaign, 1 Airport Road, Savoy, Illinois 61874
Recipient's Title and Affiliation: Innovative Technologies Corporation, Dayton, OH
URL: http://www.humanfactors.uiuc.edu/Reports&PapersPDFs/TechReport/99-06.pdf

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Reference Type: Journal Article
Author: Braithwaite, M.G; Durnford, S.J; Rosado, N.R
Year: 1998
Title: Spatial disorientation in U.S Army rotary-wing operations
Journal: Aviation, Space, and Environmental Medicine (ASEM)
Volume: 69
Pages: 1031-1037
Date: November
Abstract: This paper describes two surveys concerning spatial disorientation (SO) in U.S. Army rotary-wing operations that sought to assess the hazard and to identify recommendations to control it. One survey was of accident records, and the other was of aircrew experiences. Both surveys highlighted the magnitude of the problem. The accident survey showed that 30% of class A to C accidents involved SO as a significant factor, while the aircrew survey showed that 78% of aircrews have been disoriented (8% to the extent that flight safety was threatened). Both surveys showed a significant increase in SO associated with combat operations. Several differences between the two surveys were noted: 90% of the reviewed accidents were thought to involve type I (unrecognized) SO compared with only 43% of the reported incidents; both pilots in a particular aircraft were considered to have been disoriented in at least 59% of accidents compared with 23% of incidents; sudden loss of visual cues ("brownout," "whiteout," or inadvertent entry to instrument meteorological conditions) accounted for 25% of SO accidents compared with 13% of incidents; and 62% of the accidents occurred at night compared with only 36% of incidents. Neither survey showed any association between SO and fatigue or other human factors. The results of both surveys suggested that crew coordination, alerting devices (e.g., audio warnings on the radar altimeter), flight information displays, and autopilot functions would be good targets for improvement.

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Reference Type: Journal Article
Author: Brandt, T.; Dichgans, J.; Koenig, E.
Year: 1973
Title: Differential effects of central versus peripheral vision on egocentric and exocentric motion perception
Journal: Experimental Brain Research
Volume: 16
Pages: 476-491
Number of Pages: 16

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Reference Type: Conference Paper
Author: Brauser, K.; Seifert, R.
Year: 1985
Title: Computer simulation studies on human control reliability

Conference Name: Flight Mechanics Panel Specialists' Meeting on Piloted Aircraft Environment Simulation Techniques
Conference Location: Cambridge, United Kingdom
Publisher: Advisory Group for Aerospace Research and Development (AGARD)
Date: September 30 - October 3
Author's Title and Affiliation: Messerschmitt-Bölkow-Blohm GmbH, Ergonomics and Cockpit System LKE 301, Postfach 80 11 60, D-8000 München 80
Number of Pages: 10-1 - 10-19
Keywords: human control reliability, task taxonomy
Abstract: Pilot Induced Oscillations usually are defined as a sensitive indication of bad handling qualities. In the view of human performance reliability, PIOs are related to input errors with respect to the control characteristics of the controlled system. It has been learnt that this is a special aspect to the general rule that man will make errors while performing an arbitrary task under the influence of possible "performance shaping factors" (PSFs).
A recently developed "Task Taxonomy Method" is used as a tool for assessment of Human Error Probabilities (HEP) depending quantitatively on the effects of performance shaping factors (PSF) like task dimensions and characteristics, operator characteristics, system characteristics and environment factors. Using this Task Taxonomy procedure, HEP values for manual aircraft control tasks have been calculated. HEP values are drastically increased (0.5 - 0.9) by the influence of bad handling qualities while good handling qualities only reduce the HEP value to 0.1, because other PSFs may remain active. Therefore PIO incidents remain possible, even in aircraft with good handling qualities. This has been demonstrated by means of SAINT computer simulations using appropriate HEP values.
Notes: Published in September 1986.

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Reference Type: Report
Author: Bray, R. S.
Year: 1972
Title: Initial operating experience with an aircraft simulator having extensive lateral motion
Institution: National Aeronautics and Space Administration (NASA)
Pages: 1-21
Date: May
Type: Technical Memorandum
Report Number: NASA TM X-62,155
Author's Title and Affiliation: Ames Research Center, Moffett Field, CA
Number of Pages: 22
Abstract: Late in 1969, a new research flight simulation facility, termed the Flight Simulator for Advanced Aircraft, was put into operation at Ames Research Center. This facility features an extensive cockpit motion system, emphasizing lateral motion for the simulation of lateral-directional control tasks. This paper describes briefly the motion capabilities of the simulator, and describes in some detail the logic with which the motion drives are controlled to provide the most effective approximations of the motion of flight. Preliminary assessments of the effectiveness of these motions, in the simulation of large transport aircraft, are discussed.

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Reference Type: Journal Article
Author: Bray, Richard S.
Year: 1973
Title: A study of vertical motion requirements for landing simulation
Journal: Human Factors
Volume: 15
Issue: 6
Pages: 561-568
Author's Title and Affiliation: Ames Research Center, NASA, Moffett Field, CA

Abstract: Tests were conducted to determine the significance of vertical acceleration cues in the simulation of the visual approach to landing maneuver. Landing performance measures were obtained for four subject pilots operating a visual landing simulation mechanized in the Ames Height Control Test Apparatus, a device that provides up to +/-40 ft. of vertical motion. Test results indicate that vertical motion cues are utilized in the landing task, and that they are particularly important in the simulation of aircraft with marginal longitudinal-handling qualities. To assure vertical motion cues of the desired fidelity in the landing task, it appears that a simulator must have excursion capabilities of at least +/-20 ft.

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Reference Type: Conference Paper
Author: Bray, Richard S.
Year: 1985
Title: Visual and motion cueing in helicopter simulation
Conference Name: AGARD Flight Mechanics Panel Symposium on Flight Simulation
Conference Location: Cambridge, United Kingdom
Publisher: Advisory Group for Aerospace Research and Development (AGARD)
Date: September 30-October 3
Author's Title and Affiliation: NASA Ames Research Center, Moffett Field, CA 94035
Number of Pages: 16
Keywords: visual and motion cueing, helicopter simulation, fidelity, cockpit motion, washout
Abstract: For the past decade, helicopter handling qualities have been the subject of piloted-simulator programs at Ames Research Center. Early experience in fixed-cockpit simulators, with limited field of view, demonstrated the basic difficulties of simulating helicopter flight at the level of subjective fidelity required for confident evaluation of the vehicle characteristics. More recent programs utilizing large-amplitude cockpit motion and a multiwindow visual-simulation system have received a much higher degree of pilot acceptance However, none of these simulations has presented critical visual-flight tasks that have been accepted by pilots as the full equivalent of flight. In this paper, the visual cues presented in the simulator are compared with those of flight in an attempt to identify deficiencies that may contribute significantly to these assessments. It is suggested that a non-optimum distribution of field-of-view elements, coupled with a severe lack of near-field detail, compromises the pilots sensing of transitional rates relative to nearby terrain or landing surface. For the low-amplitude maneuvering tasks normally associated with the hover mode, the unique motion capabilities of the Vertical Motion Simulator (VMS) at Ames Research Center permit nearly a full representation of vehicle motion. Especially appreciated in these tasks are the vertical-acceleration responses to collective control. For larger-amplitude maneuvering, motion fidelity must suffer diminution through direct attenuation or through high-pass filtering "washout" of the computer cockpit accelerations or both. Experiments were conducted in an attempt to determine the effects of these distortions on pilot performance of height-control tasks. Results revealed that in holding position in the presence of vertical disturbances, pilot control-gain and resultant open-loop crossover frequency were significantly depressed as the fidelity of vertical motion was reduced. In height-tracking of a moving reference, gain and crossover were not greatly affected, but phase margin and tracking performance improved with motion fidelity. Pilot-opinion ratings of varied vertical-response characteristics were significantly modified by changes in motion-cue fidelity.
Notes: Published in September 1986.

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Reference Type: Conference Paper
Author: Bresee, J. S.; O'Neal, A. F.; Jennings, J. S.
Year: 1998
Title: Establishing relationships between flight data parameter values and instructor evaluations of performance for selected advanced qualification program qualification standards
Conference Name: International Training & Education Conference (ITEC)
Conference Location: Lausanne, Switzerland
Date: April 28-30
Number of Pages: 10

Keywords: Flight Operations Quality Assurance (FOQA), Automated Performance Management System (APMS), Advanced Qualification Program (APQ)

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Reference Type: Conference Paper
Author: Breuhaus, Waldemar O.; Harper, Robert P.
Year: 1970
Title: The selection of tasks and subjects of flight simulation experiments
Conference Name: Simulation
Conference Location: Ames Research Center, Moffett Field, CA
Publisher: Advisory Group for Aerospace Research and Development (AGARD)
Date: March
Author's Title and Affiliation: Breuhaus: Aerosciences Division Director, Cornell Aeronautical Laboratory, Inc., Buffalo, NY 14221
Harper: Assistant Head, Flight Research Department, Cornell Aeronautical Laboratory, Inc., Buffalo, NY 14221
Number of Pages: 15
Keywords: flight simulation, task selection
Abstract: The fundamental, underlying purpose of flight simulation experiments is to estimate the results of a real-world evaluation of the flight problem that is being simulated. Many factors are important in the design of the simulation experiment, and it is essential that these factors be identified and dealt with. This paper considers two important areas: the selection of the simulation tasks, and the selection and preparation of the evaluation subjects.
The limitations of various simulators directly affect the simulation tasks which can be performed and, hence, affect the validity of the evaluation results obtained. The ability of simulator pilots to produce valid and repeatable evaluations which are applicable to the real-world situation can be no better than the accuracy with which the simulator tasks represent the essential characteristics of the real world. Unfortunately, this paper does not propose to set forth these sought-for necessities--it is beyond the knowledge of the authors to do so. Instead, certain considerations in the selection of simulator tasks are discussed, and problems are set forth which should be considered explicitly in the design of simulation experiments.
The selection and preparation of evaluation pilots are discussed in terms of the factors which appear to have substantial effects upon the program results. Experience in the real-world mission is one of several key elements which greatly enhances the evaluation results, and is discussed as an aid in bridging the gap to the real world. The discussion of the preparation of subjects considers the importance and nature of communication between the subject pilot and the analyst, and participation of the subjects in the experimental design.
Notes: Lead discussion by A. Filisetti and A. D. Brown. Also contains an open discussion.

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Reference Type: Journal Article
Author: Bringoux, L.; Mezey, L. E.; Faldon, M.; Gresty, M. A.; Bronstein, A. M.
Year: 2007
Title: Influence of pitch tilts on the perception of gravity-referenced eye level in labyrinthine defective subjects
Journal: Neuropsychologia
Volume: 45
Issue: 2
Pages: 350-356
ISSN: 0028-3932
Number of Pages: 7
Accession Number: 2006-22970-016
Keywords: vestibular information, gravity referenced eye level, labyrinthine defective subjects, pitch tilts

Abstract: We investigate the role of vestibular information in judging the gravity-referenced eye level (i.e., earth-referenced horizon or GREL) during sagittal body tilt whilst seated. Ten bilateral labyrinthine-defective subjects (LDS) and 10 age-matched controls set a luminous dot to their perception of GREL in darkness, with and without arm pointing. Although judgments were linearly influenced by the magnitude of whole-body tilt, results showed no significant difference between LDS and age-matched controls in the subjective GREL accuracy or in the intra-subject variability of judgment. However, LDS performance without arm pointing was related to the degree of vestibular compensation inferred from another postural study performed with the same patients. LDS did not utilize upper limb input during arm pointing movements as a source of graviceptive information to compensate for the vestibular loss. The data suggest that vestibular cues are not of prime importance in GREL estimates in static conditions. The absence of difference between controls and LDS GREL performance, and the correlation between the postural task and GREL accuracy, indicate that somatosensory input may convey as much graviceptive information required for GREL judgements as the vestibular system.

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Reference Type: Journal Article
Author: Bringoux, Lionel; Schmerber, Sébastien; Nougier, Vincent; Dumas, Georges; Barraud, Pierre Alain; Raphel, Christian
Year: 2002
Title: Perception of slow pitch and roll body tilts in bilateral labyrinthine-defective subjects
Journal: Neuropsychologia
Volume: 40
Issue: 4
Pages: 367-372
Electronic Resource Number: 10.1016/S0028-3932(01)00103-8
Number of Pages: 6
Keywords: body tilt, body orientation, somatosensory information, labyrinthine defective, perception, slow pitch, vestibular function
Abstract: Examined whether the perception of slow body tilts in total darkness was affected by a complete loss of vestibular function. Four blindfolded bilateral labyrinthine-defective Ss (LDs) and 12 normal Ss (Normals) were seated and immobilized with large straps against the back of a rotating L-shaped platform. All Ss had a mean age of 29 yrs. Ss were asked to detect the slow change in their body orientation, by indicating as soon as possible the direction of tilt. After a brief period of practice observed for all LDs at the beginning of the session, results showed no significant difference between LDs and Normals in the mean detection threshold recorded for each direction of tilt. The mean perceptual threshold was 4.4 versus 5.1° in the roll dimension, and 6.1 versus 6.1° in the pitch dimension, for the LDs and Normals, respectively. These findings indicate that the accurate perception of body orientation in quasi-static conditions is mainly allowed by somatosensory information rather than by otolithic inputs.

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Reference Type: Report
Author: British Standards Institution
Year: 2000
Title: Quality management systems - Requirements
Institution: International Standards Organization
Date: December
Type: Standards
Report Number: ISO 901:2000
Number of Pages: 40

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Reference Type: Report
Author: Brock, John F.; Jacobs, Cynthia; Van Cott, Harold; McCauley, Michael; Norstrom, David M.
Year: 2001
Title: Simulators and bus safety: Guidelines for acquiring and using transit bus operator driving simulators
City: Washington, D.C.
Institution: Transit Cooperative Research Program
Transportation Research Board - National Research Council
Report Number: TCRP Report 72
Number of Pages: 29+appendix+glossary

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Reference Type: Journal Article
Author: Bronstein, Adolfo M.; Yardley, L.; Moore, A. P.; Cleeves, L.
Year: 1996
Title: Visually and posturally mediated tilt illusion in Parkinson's disease and in labyrinthine defective subjects
Journal: Neurology
Volume: 47
Issue: 3
Pages: 651-656
ISSN: 0028-3878 (Print)
1526-632X (Electronic)
Number of Pages: 6
Keywords: visually & posturally mediated tilt illusion, 24-80 yr old Parkinson's disease vs bilateral labyrinthine defective patients
Abstract: Tested 24 normal Ss, 24 patients with idiopathic Parkinson's disease (PD), and 8 patients (all Ss aged 24–80 yrs) with bilateral absence of vestibular function (labyrinthine defective [LD] Ss) in their ability to set a straight line to the perceived gravitational vertical (visual vertical). Measurements were taken in static conditions, sitting upright, and lying down on the right side, and during visual background motion at constant angular velocities around the line of sight (roll-motion) in both sitting upright and sideways position. LD patients showed abnormally large deviations of the visual vertical induced both by lateral body tilt and by visual roll-motion. This suggests that vestibular cues play a significant part in counterbalancing visually and proprioceptive mediated biases on the perception of verticality. In contrast, PD patients were normal in all these tasks indicating that visual dependence in PD is not present at an afferent/perceptual level.

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Reference Type: Conference Paper
Author: Brown, Charles D.
Year: 1978
Title: Current deficiencies in simulation for training
Conference Name: Flight Mechanics Panel Specialists' Meeting on Piloted Aircraft Environment Simulation Techniques
Conference Location: Brussels, Belgium
Publisher: Advisory Group for Aerospace Research and Development (AGARD)
Date: April 24-27
Author's Title and Affiliation: Colonel, United States Air Force, Tactical Air Warfare Center (USAFTAWC)
Number of Pages: 7
Keywords: flight simulation, deficiencies

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Reference Type: Report
Author: Brown, Yorke J.; Cardullo, Frank M.; McMillan, Grant R. ; Riccio, Gary E.; Sinacori, John B.
Year: 1991
Title: New approaches to motion cueing in flight simulators
City: Wright-Patterson Air Force Base, OH
Date: September
Type: Final Report
Report Number: AL-TR-1991-0139
Author's Title and Affiliation: Brown, Cardullo, McMillan, Riccio: Cardullo, Brown, & Associates, State University of New York
Sinacori: John B. Sinacori Associates, University of Illinois
Recipient's Title and Affiliation: Armstrong Laboratory, Crew Systems Directorate, Human Engineering Division, Human Systems Center, Air Force Systems Command, Wright-Patterson AFB, OH 45433-7022
Keywords: motion cueing
Abstract: A study was conducted to investigate new approaches in motion simulation. The study developed a conceptual model of pilot control of an aircraft. This model was subsequently used in a "need-based" analysis of motion cueing devices. This analysis technique involved a frequency domain representation of aircraft maneuvers, pilot perception of these maneuvers, and pilot perception of the cues from various simulator cueing devices. The analysis led to an assessment founded upon principles of pilot perception and behavior. An analysis task was performed on a pop-up attack in an F-4 aircraft to generate the aircraft maneuver time histories and pilot cue matrix. The results were used in a frequency domain analysis to determine the value of cueing devices for particular portions of the maneuver. The study investigated various cueing techniques beginning with proposed optimization of existing devices and proceeding to discuss several new techniques such as vibromyesthetic stimulation and direct electrical stimulation of nerves and muscles. The report concludes with recommendations for (1) future work employing the newly developed analytical technique and (2) experimentation with selected new devices to determine their cueing value.

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Reference Type: Conference Paper
Author: Brown, Yorke J.; Cardullo, Frank M.; Sinacori, John B.
Year: 1989
Title: Need-based evaluation of simulator force and motion cuing devices
Conference Name: AIAA Flight Simulation Technologies Conference
Conference Location: Boston, MA
Publisher: American Institute of Aeronautics and Astronautics (AIAA)
Electronic Resource Number: AIAA 89-3272-CP
Author's Title and Affiliation: Brown: Member of AIAA, Cardullo, Brown and Associates, Binghamton, NY
Cardullo: Member of AIAA, State University of New York, Binghamton, NY
Sinacori: Member of AIAA, John B. Sinacori Associates, Pebble Beach, CA
Number of Pages: 8
Keywords: pilot sensation of motion cues, force and motion cueing, mission profile, aircraft response, pilot sensory system response, and simulator cuing device performance
Abstract: Since aircraft--and particularly military aircraft--can produce sustained periods of significant acceleration, whereas ground based simulators cannot, the technical problem of providing faithful force and motion cues in a simulator is particularly difficult. Many force and motion cuing strategies and devices have been proposed, and many have been tested, but opinion remains divided as to the effectiveness of, or even the need for, such equipment. We have developed a method for analyzing the dynamic properties of force and motion cuing in terms of the relationship between the pilot sensation of motion cues involved in typical aircraft maneuvers and the pilot sensation of the corresponding synthetic cues produced by a simulator equipped with force and motion cuing devices. This analytic method will serve to characterize the applicability of available devices, indicate areas of fruitful development of new technologies, and guide research aimed at resolving applicability and usefulness issues. The analytic technique involves identifying the motions typical of operational flight maneuvers and then characterizing

the pilot's sensory response to the resulting accelerations and forces in the frequency domain. When a corresponding spectrum for the sensation of synthetic stimuli is overlaid, quantitative comparisons may be made. The analysis effectively integrates the relevant effects of mission profile, aircraft response, pilot sensory system response, and simulator cuing device performance into a unified graphical presentation.

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Reference Type: Conference Paper
Author: Brunt, Mark A.
Year: 1985
Title: Use of VDU's by flight simulator instructors
Conference Name: Flight Mechanics Panel Symposium on Flight Simulation
Conference Location: Cambridge, United Kingdom
Publisher: Advisory Group for Aerospace Research and Development (AGARD)
Date: September 30 - October 3
Author's Title and Affiliation: Human Factors Consultant, Research & Development Department, Rediffusion Simulation Limited, Gatwick Road, Crawley, RH10 2RL, United Kingdom
Number of Pages: 6
Keywords: VDU, flight simulator instructors
Abstract: This paper compares the development of VDU-based simulator instructor stations with some Ergonomics rules, and provides a discussion around design aims and practical experience. Further rules are developed to establish a baseline for designers, procurers and users of instructor stations.
Notes: Published in September 1986.

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Reference Type: Report
Author: Bryant, Richard Barry; Douglass, D. Scott; Ewart, Ronald; Slutz, Jeff Gary
Year: 1992
Title: Dynamic latency measurement using the Simulator Network Analysis Project (SNAP)
City: Wright-Patterson Air Force Base, OH
Institution: Wright-Patterson Air Force Base
Author's Title and Affiliation: Bryant, Douglass, Ewart: WL/FIGD, 2180 8th St., WPAFB, OH 45433 Slutz: EAI Services, Division of Halifax Corporation, 2180 8th St., WPAFB, OH 45433
Number of Pages: 9
Keywords: SNAP, simulator network analysis project, network latencies, simulation accuracy, protocol data units, network delays, EVDAS, electronic visual display altitude sensor, distributed interactive simulation
Abstract: This document outlines the SNAP project, its goals, its requirements, hardware and software, the verification and the experiments involved.

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Reference Type: Conference Paper
Author: Buffett, A. R.
Year: 1986
Title: Visual cueing requirements in flight simulation
Conference Name: RAeS Advances in Flight Simulation - Visual and Motion Systems
Number of Pages: 31
Abstract: The aim of this lecture is to examine the requirements for visual cueing in flight simulators and the principles on which the provision of such cues are based. The information needs and perceptual capabilities of the human operators will necessarily be considered, along with the nature of the tasks for which the simulators may be used. This will indicate the particular cues which would ideally be provided in specific situations, and the extent to which current simulator visual systems are able to meet such requirements.

Reference Type: Report
Author: Bull, John; Mah, Robert; Davis, Gloria; Conley, Joe; Hardy, Gordon; Gibson, Jim; Blake, Matthew; Bryant, Don; Williams, Diane
Year: 1995
Title: Piloted simulation tests of propulsion control as backup to loss of primary flight controls for a mid-size jet transport
City: Moffett Field, CA
Institution: National Aeronautics and Space Administration (NASA)
Date: December
Type: NASA Technical Memorandum
Report Number: NASA TM-110374
Author's Title and Affiliation: Bull - CAELUM Research Corporation
Mah, Davis, Conley, Hardy, Blake - NASA Ames Research Center
Gibson - Recom Technologies
Bryant, Williams - ManTech/NSI Technology Services Corporation
Number of Pages: 32
Keywords: propulsion control, jet transport, piloted simulation
Abstract: Failures of aircraft primary flight-control systems to aircraft during flight have led to catastrophic accidents with subsequent loss of lives (e.g., DC-10 crash, B-747 crash, C-5 crash, B-52 crash, and others). Dryden Flight Research Center (DFRC) investigated the use of engine thrust for emergency flight control of several airplanes, including the B-720, Lear 24, F-15, C-402, and B-747. A series of three piloted simulation tests have been conducted at Ames Research Center to investigate propulsion control for safely landing a medium size jet transport which has experienced a total primary flight-control failure. The first series of tests was completed in July 1992 and defined the best interface for the pilot commands to drive the engines. The second series of tests was completed in August 1994 and investigated propulsion controlled aircraft (PCA) display requirements and various command modes. The third series of tests was completed in May 1995 and investigated PCA full-flight envelope capabilities. This report describes the concept of a PCA, discusses pilot controls, displays, and procedures; and presents the results of piloted simulation evaluations of the concept by a cross-section of air transport pilots.

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Reference Type: Report
Author: Burcham, Frank W. Jr.; Maine, Trindel A.
Year: 1998
Title: Using engine thrust for emergency flight control: MD-11 and B-747 results
City: Edwards, CA
Institution: National Aeronautics and Space Administration (NASA)
Date: May
Report Number: NASA/TM-1998-206552
Number of Pages: 27
Abstract: With modern digital control systems, using engine thrust for emergency flight control to supplement or replace failed aircraft normal flight controls has become a practical consideration. The NASA Dryden Flight Research Center has developed a propulsion-controlled aircraft (PCA) system in which computer-controlled engine thrust provides emergency flight control. An F-15 and an MD-11 airplane have been landed without using any flight control surfaces. Preliminary studies have also been conducted that show that engines on only one wing can provide some flight control capability if the lateral center of gravity can be shifted toward the side of the airplane that has the operating engine(s). Simulator tests of several airplanes with no flight control surfaces operating and all engines out on the left wing have all shown positive control capability within the available range of lateral center-of-gravity offset. Propulsion-controlled aircraft systems that can operate without modifications to engine control systems, thus allowing PCA technology to be installed on less capable airplanes or at low cost, are also desirable. Further studies have examined simplified "PCA Lite" and "PCA Ultralite" concepts in which thrust control is provided by existing systems such as autothrottles or a combination of existing systems and manual pilot control.

Reference Type: Report
Author: Burcham, Patricia M.
Year: 2002
Title: Motion sickness literature search
Institution: Army Research Laboratory (ARL)
Report Number: ARL-MR-504
Author's Title and Affiliation: Human Research & Engineering Directorate, Army Research Laboratory, Aberdeen Proving Ground, MD 21005-5425
Keywords: motion sickness, simulator sickness
Abstract: A review of the literature about motion-induced cognitive and perceptual decrements and about motion sickness was conducted to identify screening methods and mitigation techniques to gain estimates of the portion of population affected. Screening and mitigation techniques that show promise for indirect driving will be evaluated in imminent laboratory and field experiments.
URL: http://stinet.dtic.mil/oai/oai?&verb=getRecord&metadataPrefix=html&identifier=ADA402963

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Reference Type: Magazine Article
Author: Burin, James M.
Year: 2008
Title: LOC up
Magazine: AeroSafety World
Volume: 3
Issue Number: 2
Pages: 12-17
Date: February
Author's Title and Affiliation: Director of Technical Programs, Flight Safety Foundation
Number of Pages: 6
Keywords: upset recovery training (URT), loss of control
Abstract: Loss of control accidents replaced CFIT as the leading cause of commercial aviation fatalities in 2007.
URL: http://www.flightsafety.org/asw/feb08/asw_feb08_p12-17.pdf

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Reference Type: Magazine Article
Author: Burke, Robert
Year: 2002
Title: Can smart planes avoid crashing?
Magazine: Virginia Business
Date: September
Keywords: refuse-to-crash, upset recovery training (URT)
Abstract: NASA Langley is building a system that could stop terrorists, but applying it is hard.

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Reference Type: Report
Author: Bürki-Cohen, J.
Year: 1995
Title: An analysis of tower (ground) controller - pilot voice communications
City: Washington, DC
Date: November
Report Number: DOT/FAA/AR-96/19
URL: http://www.volpe.dot.gov/hf/docs/ground2.doc

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Reference Type: Conference Paper
Author: Bürki-Cohen, J.
Year: 1995
Title: Say again? How complexity and format of air traffic control instructions affect pilot recall
Conference Name: 40th Annual Air Traffic Control Association Convention
Conference Location: Las Vegas, Nevada
Date: September 10-14
Abstract: Until recently, controllers were required to communicate all numerical air traffic control (ATC) information in sequential format, that is, digit by digit. For example, an altitude of 17,000 ft had to be transmitted as "Climb to one seven thousand." According to the latest versions of the Air Traffic Control handbook (7110.65G), however, controllers may restate altitude clearances in grouped format as "seventeen thousand" after giving them in sequential format. Although controllers appear to generally agree that grouping numbers improves recall, there is no direct scientific evidence to support this belief. This study compared the recall of ATC information presented in either grouped or sequential format in a part-task simulation. It also tested the effect of complexity of ATC clearances on recall, that is, how many pieces of information a single transmission may contain without resulting in a readback error.
URL: http://www.volpe.dot.gov/hf/docs/atcafinal.doc

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Reference Type: Book Section
Author: Bürki-Cohen, J.
Year: 1996
Title: How to say it and how much: The effect of format and complexity on pilot recall of air traffic control clearances
Editor: Kanki, B.G.; Prinzo, V.O.
Book Title: Methods and Metrics of Voice Communications
Volume: DOT/FAA/AM-96/10

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Reference Type: Transcript
Author: Bürki-Cohen, J.
Year of Meeting: 1996
Title: Transcript of the joint FAA/industry symposium on level B airplane simulator aeromodel validation requirements
Meeting Location: Washington Dulles Airport Hilton
Publisher: Federal Aviation Administration (FAA)
Date: March 13-14
URL: http://www.volpe.dot.gov/hf/docs/valreqma.html

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Reference Type: Transcript
Author: Bürki-Cohen, J.
Year of Meeting: 1996
Title: Transcript of the joint FAA/industry symposium on level B airplane simulator motion requirements
Meeting Location: Washington Dulles Airport Hilton
Publisher: Federal Aviation Administration (FAA)
Date: June 19-20
URL: http://www.volpe.dot.gov/hf/docs/valreqju.html

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Reference Type: Conference Paper
Author: Bürki-Cohen, J.
Year: 2003
Title: Evidence for the need of realistic radio communications for airline pilot simulator training and evaluation
Conference Name: International Conference Simulation of the Environment
Conference Location: London, UK
Publisher: Royal Aeronautical Society (RAeS)
Date: November 5-6
Abstract: This paper presents arguments in favor of realistic representation of radio communications during training and evaluation of airline pilots in the simulator. A survey of airlines showed that radio communications are mainly role-played by Instructor/Evaluators (I/Es), which increases I/E workload but reduces pilot workload. Opinions gathered from I/Es and the literature indicate that this may lead to inadequate preparation of pilots to handle the complex radio-communications environment encountered in the air. A look at incidents during Initial Operating Experience (IOE) in revenue service via a review of the Aviation Safety Reporting System (ASRS) give additional support to this hypothesis. The paper concludes with a discussion of industry and airline efforts to find alternative means to provide realistic radio communications.
URL: http://www.volpe.dot.gov/hf/docs/raes-2003.pdf

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Reference Type: Conference Paper
Author: Bürki-Cohen, J.; Boothe, E.M.; Soja, N.N.; DiSario, R.; Go, T. H.; Longridge, T.
Year: 2000
Title: Simulator fidelity: The effect of platform motion
Conference Name: International Conference Flight Simulation--The Next Decade
Conference Location: London, UK
Publisher: Royal Aeronautical Society
Date: May 10-12
Author's Title and Affiliation: Volpe Center Flight Deck Human Factors
Abstract: This research is part of the Federal Aviation Administration's (FAA) initiative towards promoting affordable flight simulators for U.S. commuter airline training. This initiative becomes even more important as the FAA is considering regulatory action that will mandate the use of simulators for all air carrier flight-crew training and qualification. Consequently, sound scientific data on the relationship between certain simulator features such as platform motion and their effect on the transfer of pilot performance and behavior to and from the respective airplane become very important. The present study examined the effect of platform motion (i.e., FAA qualified Level C six-degree-of-freedom synergistic motion) in the presence of a high-quality wide-angle visual system on 1) pilot performance and behavior for evaluation prior to any repeated practice or training, 2) the course of training in the simulator, and 3) the transfer of skills acquired during training in the simulator with or without motion to the simulator with motion as a stand-in for the airplane (quasi-transfer design). Every effort was made to avoid deficiencies in the research design identified in a review of prior studies, by measuring pilot stimulation and response, testing both maneuvers and pilots that are diagnostic of a need of motion, avoiding pilot and instructor bias, and ensuring sufficient statistical power to capture operationally relevant effects. Results of the analyses and their implications are presented in this paper.
URL: http://www.volpe.dot.gov/hf/docs/raes-2000.doc

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Reference Type: Conference Paper
Author: Bürki-Cohen, J.; Go, T. H.
Year: 2005
Title: The effect of simulator motion cues on initial training of airline pilots
Conference Name: AIAA Modeling and Simulation Technologies Conference
Conference Location: San Francisco, CA

Publisher: American Institute of Aeronautics and Astronautics (AIAA)
Date: August 15-18
Electronic Resource Number: AIAA 2005-6109
Author's Title and Affiliation: Bürki-Cohen: Engineering Psychologist, Human Factors Division, Volpe National Transportation Systems Center, USDOT/RITA, Cambridge, MA
Go: Aerospace Research Engineer, Center for Transportation and Logistics, Massachusetts Institute of Technology, Cambridge, MA
Abstract: Two earlier studies conducted in the framework of the Federal Aviation Administration/Volpe Flight Simulator Human Factors Program examining the effect of simulator motion on recurrent training and evaluation of airline pilots have found that in the presence of a state-of-the-art visual systems, motion provided by a six-degree-of-freedom platform-motion system only minimally affected evaluation, and did not benefit training, of pilots that were familiar with the airplane. This paper gives preliminary results of a study on the effect of simulator platform motion on initial training of airline pilots that have never flown the simulated airplane.
Notes: First, the study confirmed the small but statistically significant alerting effect of motion found in the recurrent study with enhanced motion, although for initial training, the effect was only marginally significant. Even forewarned of an engine failure, pilots without motion cues remained unable to respond to an engine failure on take-off as fast as pilots with motion cues. It also showed, however, that like experienced pilots, pilots unfamiliar with the motion cues encountered in the airplane were able to catch up immediately once they receive motion cues, in other words, they did not have to be trained with motion to recognize the cues signaling an engine failure on takeoff. During the transfer portion of the study, all pilots responded equally fast for the V1 cut, regardless of the simulator configuration employed during training. With platform motion, the no-motion trained pilots improved significantly in response time, presumably because the motion cues alerted them to the engine failure.
Second, for the V1 cut only, motion appeared to help pilots to keep the column steady, which in turn helped them with airspeed--but not pitch angle-control. Recurrent pilots in the simulator with enhanced motion had controlled pitch angle better with motion, but only during the very first exposure to the V1 cut. Already with the second V1 cut, which was still flown without motion by the no-motion group, the difference between groups was gone. For both studies, the effects were small, and their operational relevance will need to be assessed by the operators themselves.
Third, although both groups improved on many variables for the ILS approach between training and transfer of training, the only group effect found was steadier pedal control for the no-motion group throughout. The recurrent study with enhanced motion had also found an overall steadier control strategy for the no-motion group, but for the wheel, not for the pedal. Also, the improved flight precision without motion found for recurrent pilots was not replicated with initial pilots.
Fourth, participants' perceptions did not indicate a marked preference for either of the two conditions. Most importantly, again there was no evidence that the sensory conflict between eyes and vestibular apparatus induced discomfort in the no-motion condition.
URL: http://www.volpe.dot.gov/hf/docs/aiaa-2005-6109.doc

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Reference Type: Conference Paper
Author: Bürki-Cohen, J.; Go, T. H.; Chung, W. W.; Schroeder, J.; Jacobs, S.; Longridge, T.
Year: 2003
Title: Simulator fidelity requirements for airline pilot training and evaluation continued: An update on motion requirements research
Conference Name: International Symposium on Aviation Psychology (ISAP)
Conference Location: Dayton, OH
Date: April 14-17
Abstract: Preliminary results are presented on the effect of enhanced hexapod motion on airline pilot recurrent evaluation, training, and transfer of training to the simulator with motion as a stand-in for the airplane (quasi-transfer). A first study, which tested "as is" motion in an FAA qualified full flight simulator, had not found any effect of motion. Under the enhanced motion conditions of the present study many effects of motion emerged that have not been previously shown in the airline-pilot training and evaluation

context, indicating that motion may be required at least for pilot evaluation purposes. The implications of the results for recurrent training are also discussed.
URL: http://www.volpe.dot.gov/hf/docs/isap-2003.doc

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Reference Type: Conference Paper
Author: Bürki-Cohen, J.; Go, Tiauw H.; Longridge, Thomas
Year: 2001
Title: Flight simulator fidelity considerations for total airline pilot training and evaluation
Conference Name: AIAA Modeling and Simulation Technologies Conference
Conference Location: Montreal, Canada
Publisher: American Institute for Aeronautics and Astronautics (AIAA)
Date: August 6-9
Electronic Resource Number: AIAA 2001-4425
Author's Title and Affiliation: Bürki-Cohen Volpe National Transportation Systems Center, U.S. Department of Transportation Research and Special Programs Administration, Cambridge, Massachusetts
Go: Postdoctoral Associate, Department of Aeronautics and Astronautics, Massachusetts Institute of Technology, Cambridge, Massachusetts
Longridge: Manager, Advanced Qualification Program, AFS-230, Federal Aviation Administration, Washington, D.C.
Number of Pages: 9
Abstract: This paper presents the FAA/Volpe Center's Flight Simulator Fidelity Research Program, which is part of the Federal Aviation Administration's effort to promote effectiveness, availability and affordability of flight simulators. This initiative will become increasingly critical with the anticipated regulatory changes mandating the use of simulators in airline pilot training and evaluation, dramatically reduced pilot new-hire experience levels and growing operational complexity. Two research areas with high pay-off potential for this effort are radio communications and platform motion simulation. Initial results suggest that to be fully effective in training and evaluating the cognitive and workload skills associated with radio communications, significant improvements in radio communications realism are needed. Initial research on the training effectiveness of a fixed-base simulator with a wide field-of-view visual system compared to a like system having platform motion failed to find an operationally significant effect of motion. Follow-up work will examine whether this result was a function of the motion characteristics or the maneuvers tested. No changes in regulatory requirements can be expected without absolute confidence in the reliability and validity of the results, requiring considerable additional research in both areas.
URL: http://www.volpe.dot.gov/hf/docs/aiaa-2001-4425.doc

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Reference Type: Journal Article
Author: Bürki-Cohen, J.; Kendra, Andrew J.
Year: 2001
Title: Air traffic control in airline pilot simulator training and evaluation
Journal: Air Traffic Control Quarterly
Volume: 9
Issue: 3
Pages: 229-253
Abstract: Much airline pilot training and checking occurs entirely in the simulator, and the first time a pilot flies a particular airplane, it may carry passengers. Simulator qualification standards, however, focus on the simulation of the airplane without reference to the air traffic environment. This paper describes research examining the question of whether simulator pilot training and evaluation would benefit from improved simulation of radio communications. First, existing radio communication simulation practices were investigated. Second, opinions from instructors/evaluators were solicited. Third, the pertinent literature was reviewed. Fourth, the effectiveness of current practices was evaluated by surveying the Aviation Safety Reporting System. Finally, recent efforts to improve radio communication simulation were

examined. The paper concludes that there is much evidence that increasing the realism of radio communications would improve simulator training and evaluation of airline pilots, but that finding effective ways to do so will depend on collaboration of government, industry, military and academia.
URL: http://www.volpe.dot.gov/hf/docs/atcq-v9n3-01.doc

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Reference Type: Report
Author: Bürki-Cohen, J.; Kendra, A.J.; Kanki, B.G.; Lee, A.T.
Year: 2000
Title: Realistic radio communications in pilot simulator training
City: Washington, DC
Report Number: DOT/FAA/AR-00/13
Keywords: air traffic control communications, company communications, flight simulator, airline pilot training and evaluation, advanced qualification program, crew resource management, task management, situation awareness, realism
Abstract: Simulators used for total training and evaluation of airline pilots must satisfy stringent criteria in order to assure their adequacy for training and checking maneuvers. Air traffic control and company radio communications simulation, however, may still be left to role-play by the already taxed instructor/evaluators in spite of their central importance in every aspect of the flight environment. The underlying premise of this research is that providing a realistic radio communications environment would increase safety by enhancing pilot training and evaluation.
This report summarizes the first-year efforts of assessing the requirement and feasibility of simulating radio communications automatically. A review of the training and crew resource/task management literature showed both practical and theoretical support for the need for realistic radio communications simulation. A survey of 29 instructor/evaluators from 14 airlines revealed that radio communications are mainly role-played by the instructor/evaluators. This increases instructor/evaluators' own workload while unrealistically lowering pilot communications load compared to actual operations, with a concomitant loss in training/evaluation effectiveness. A technology review searching for an automated means of providing radio communications to and from aircraft with minimal human effort showed that while promising, the technology is still immature. Further research and the need for establishing a proof of concept are also discussed.
URL: http://www.volpe.dot.gov/hf/docs/rrcrprt.html

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Reference Type: Conference Paper
Author: Bürki-Cohen, Judith; Soja, Nancy N.; Longridge, Thomas
Year: 1998
Title: Simulator fidelity requirements: The case of platform motion
Conference Name: International Training & Education Conference (ITEC)
Conference Location: Lausanne, Switzerland
Publisher: Computer Multimedia Productions Corporation
Date: April 28-30
Author's Title and Affiliation: Bürki-Cohen: Volpe National Transportation Systems Center, Cambridge, MA
Soja: Consultant, Brookline, MA
Longridge: Federal Aviation Administration, Washington, DC
Number of Pages: 16
Abstract: Today, the use of airplane simulators in pilot training and evaluation is universal. Simulators not only enable savings in training cost, but they have also practically eliminated training accidents for major airlines. They allow the training of emergency maneuvers which are inherently unsafe in the aircraft; and they permit crews to gain experience in operationally realistic scenarios that focus on both technical and crew resource management skills. In fact, initiatives such as the Federal Aviation Administration's (FAA) Advanced Qualification Program (SFAR 58, 1990), which heavily relies on crew resource management and need-based proficiency objectives, would be unthinkable without ready

access to a full flight simulator. Nevertheless, some regional airlines elect to do at least their recurrent training in the airplane. In part, this situation is due to a shortage of qualified simulators, especially for certain turboprop airplanes where the flight test data is not readily available. A second, and perhaps even more important, reason can be found in the high rental and purchase costs for full flight simulators, which, for small turboprops, may even exceed the cost of the airplane.
URL: http://www.volpe.dot.gov/hf/docs/itec-1998.doc

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Reference Type: Journal Article
Author: Bürki-Cohen, J.; Soja, N. N.; Longridge, T.
Year: 1998
Title: Simulator platform motion--The need revisited
Journal: International Journal of Aviation Psychology (IJAP)
Volume: 8
Issue: 3
Pages: 293-317
Type of Article: Literature Review and Research Issues
Author's Title and Affiliation: Bürki-Cohen: U.S. Department of Transportation-Volpe Center
Soja: Consultant
Longridge: Federal Aviation Administration (FAA)
Number of Pages: 25
Abstract: The need to provide increased access to flight simulator training for US regional airlines, which historically have been limited by cost considerations in the use of such equipment for pilot recurrent training, is discussed. In light of that need, that issue of whether more affordable fixed-base simulators, identical to full flight simulators in all respects except for absence of platform motion, might provide an equivalent level of safety when employed for recurrent training, is examined. Pertinent literature form the past two decades is reviewed. The paper observes that no definitive conclusion can be drawn that would warrant modification of current qualification requirements for platform motion in full flight simulators. The article concludes that this situation will remain unchanged unless new research is undertaken, which takes into account the lessons learned from past research, and the opportunities engendered by new technology. Broad guidelines for an appropriate research design are discussed.
URL: http://www.volpe.dot.gov/hf/docs/ijap_v8n3-98.doc

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Reference Type: Conference Proceedings
Author: Bürki-Cohen, Judith; Sparko, Andrea L.
Year of Conference: 2008
Title: Airplane upset prevention research needs
Conference Name: AIAA Modeling and Simulation Technologies Conference
Conference Location: Honolulu, HI
Publisher: American Institute of Aeronautics and Astronautics (AIAA)
Date: August 18-21
Electronic Resource Number: AIAA 2008-6871
Author's Title and Affiliation: Engineering Psychologists, Human Factors Division, U.S.DOT/RITA/Volpe Center, Cambridge, MA
Keywords: upset recovery training (URT), loss of control (LOC), research needs
Abstract: This paper, which concludes the Upset Recovery Session convened and chaired by Dennis Crider from the National Transportation Safety Board and the first author at the AIAA Modeling and Simulation Technologies Conference 2008, provides a broad overview of different efforts to prevent airplanes from entering unusual attitudes via Standard Operating Procedures, different types of training tools, and airplane-control-protection and flight-deck technologies. The emphasis will be on providing information that will help determine which research efforts may be most productive in reducing loss of control accidents.
URL: http://www.volpe.dot.gov/hf/docs/aiaa2008mst.pdf

Reference Type: Conference Proceedings
Author: Bürki-Cohen, Judith; Sparko, Andrea L.; Go, Tiauw H.
Year of Conference: 2007
Title: Training value of a fixed-base flight simulator with a dynamic seat
Conference Name: AIAA Modeling and Simulation Technologies Conference and Exhibit
Conference Location: Hilton Head, SC
Publisher: American Institute of Aeronautics and Astronautics (AIAA)
Date: August 20-23
Electronic Resource Number: AIAA 2007-6564
Author's Title and Affiliation: Bürki-Cohen: Engineering Psychologist, Human Factors Division, USDOT/RITA/Volpe National Transportation Systems Center, Cambridge, MA
Sparko: Engineering Psychologist, Human Factors Division, USDOT/RITA/Volpe National Transportation Systems Center, Cambridge, MA
Go: Assistant Professor, School of Mechanical and Aerospace Engineering, Nanyang Technological University, Singapore
Abstract: In this paper, we first explain that pilots experience airplane motion via multiple perceptual systems, which makes motion a candidate for simulation via stimulation of only a subset of these systems. Next, we discuss the relative merit of vestibular cues when piloting an airplane. This is followed by a comparison of the vestibular cues received in the airplane and those possible, or practicable, in an airline-pilot training simulator, considering also the history of flight-simulator motion and alternative technologies. We conclude that a vast body of research has shown that accurate cues are not achievable at present, and that those available have not been shown to improve transfer between airplane and simulator. We then examine the cost of motion, and posit that it may prohibit some airline pilots from reaping the benefits of simulator training, with a concomitant loss in passenger safety. This consideration is especially pertinent given the world-wide training needs. Moreover, the equipment, facility, and maintenance costs associated with hexapod-platform motion systems may serve to discourage operators from upgrading the simulator’s fidelity in other important areas, such as assuring that the simulator cockpit does in fact match the equipment in the target aircraft, and that the simulation includes realistic operational representation of the national air space, including the air-traffic-control environment. We describe current and planned research on the training effectiveness of an alternative approach, which provides trainees with visual motion and heave-onset cues in what otherwise corresponds to an FAA Level D Full Flight Simulator in terms of data fidelity. This includes the results of a “proof-of-concept” phase that culminated in the successful type-rating of six pilots on a twin-engine turboprop airplane.
URL: http://www.volpe.dot.gov/hf/docs/aiaa-2007-6564.doc

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Reference Type: Conference Proceedings
Author: BÜrki-Cohen, Judith; Sparko, Andrea L.; Jo, Young Jin
Year of Conference: 2009
Title: Effects of visual, seat, and platform motion during flight simulator air transport pilot training and evaluation
Conference Name: 15th International Symposium on Aviation Psychology
Conference Location: Dayton, Ohio
Date: April 27-30
Number of Pages: 6
Abstract: Access to affordable and effective flight-simulation training devices (FSTDs) is critical to safely train airline crews in aviating, navigating, communicating, making decisions, and managing flight-deck and crew resources. This paper provides an overview of the Federal Aviation Administration-Volpe Center Flight Simulator Human Factors Program examining the requirements for the qualification and use of FSTDs. We will summarize past research investigating the need for a full hexapod-platform motion system, describe regulatory and industry developments, and report on current activities.

Reference Type: Magazine Article
Author: Burnham, Frank
Year: 1987
Title: Flight simulation: Hindrance or help in teaching to fly?
Magazine: Airport Services Management
Pages: 47-48, 57-58, 60
Date: October
Number of Pages: 5
Keywords: flight simulation, enclosed cockpit environment, desk-top training devices
Abstract: Computers have enabled the development of an array of devices that simulate an aircraft in flight. While some of these offer students quality practice at a reasonable price, others are no more than toys.

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Reference Type: Book Section
Author: Burr, David C.
Year: 2002
Title: Motion perception, elementary mechanisms
Book Title: Handbook of Brain Theory and Neural Networks
Abstract: Visual motion is essential for many aspects of biological function, including rapidly detecting predators and prey, navigating through the visual environment, and constructing a three-dimensional visual representation from two-dimensional retinal input. However, motion information is not provided by the instantaneous retinal signal, but has to be computed from temporal variations in luminance over the image. Although the neural mechanisms that achieve this vary considerably throughout the animal kingdom, the underlying principles of the algorithms seem to be very similar.
Notes: Draft version Jan. 30, 2002
URL: http://www.pisavisionlab.org/downloads/motion_burr.pdf
http://wexler.free.fr/library/files/burr%20(0)%20motion%20perception,%20elementary%20mechanisms.pdf

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Reference Type: Magazine Article
Author: Business & Commercial Aviation
Year: 2004
Title: Inflight visual illusions
Magazine: Business & Commercial Aviation
Pages: 52-52
Date: September 1
Keywords: upset recovery training (URT)
Abstract: Part of any recurrent training program should be a review of the various visual and sensory illusions to which pilots may succumb and that lead to spatial disorientation. The following descriptions of the more common illusions are excerpted from the Aeronautical Information Manual, Section 8-1-5, "Illusions in Flight."

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Reference Type: Report
Author: Bussolari, Steven R.; Lee, Alfred T.
Year: 1986
Title: The effects of flight simulator motion on pilot performance and simulator acceptability in transport category aircraft
Institution: Massachusetts Institute of Technology/NASA Ames Research Center
Number of Pages: 6
Abstract: A series of quantitative models for human spatial orientation have been developed and applied to the assessment of flight simulator motion fidelity. A study was conducted to determine the effects of

alterations in flight simulator motion upon pilot performance and opinion. Eighteen airline pilots, currently flying the Boeing 727 were given a series of flight scenarios in a Phase II simulator of that aircraft under varying conditions of simulator motion. The scenarios were chosen to reflect the flight maneuvers that these pilots might encounter during a routine pilot proficiency check. Pilot performance was measured during the simulated flights and they were asked to evaluate the simulator fidelity in comparison with the actual aircraft. No significant differences in pilot performance or rating of simulator fidelity was observed, despite large differences in the amplitude of simulator platform motion. The lack of sensitivity to simulator motion is predicted by estimates of pilot motion sensation generated with the spatial orientation models.

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Reference Type: Conference Paper
Author: Bussolari, Steven R.; Sullivan, R. Bryan; Young, Laurence R.
Year: 1986
Title: Vestibular models for design and evaluation of flight simulator motion
Conference Name: Advances in Flight Simulation: Visual and Motion Systems
Conference Location: London
Publisher: Royal Aeronautical Society (RAeS)
Author's Title and Affiliation: Massachusetts Institute of Technology, Man-Vehicle Laboratory, Cambridge, MA
Number of Pages: 11
Abstract: Quantitative models for the dynamics of the human vestibular system have been applied to the generation of flight simulator platform motion. An optimal simulator motion control algorithm has been generated to minimize the vector difference between perceived spatial orientation estimated in flight and in simulation. The motion controller has been implemented on the motion system of the Vertical Motion Simulator at NASA Ames Research Center and evaluated experimentally through measurement of pilot performance and subjective rating during a VTOL aircraft simulation. In general, pilot performance in a longitudinal tracking task (formation flight) did not appear to be sensitive to variations in platform motion condition as long as motion was present. However, pilot compensation required to perform the flight tasks, as reflected in Cooper-Harper ratings of vehicle handling qualities and the direct assessment of motion fidelity by means of a rating scale designed for this purpose, were sensitive to motion controller design. The experiments generally validate the use of spatial orientation models in the design and evaluation of control systems for motion-base flight simulators.

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Reference Type: Conference Paper
Author: Bussolari, Steven R.; Young, Laurence R.; Lee, Alfred T.
Year: 1987
Title: The use of vestibular models for design and evaluation of flight simulator motion
Conference Name: Aerospace Medical Panel Symposium on Motion Cues in Flight Simulation and Simulator Induced Sickness
Conference Location: Brussels, Belgium
Publisher: Advisory Group for Aerospace Research and Development (AGARD)
Date: September 29
Author's Title and Affiliation: Bussolari: Ph.D., Massachusetts Institute of Technology, Man-Vehicle Laboratory, Room 37-219, Cambridge, MA
Young: Sc.D., Massachusetts Institute of Technology, Man-Vehicle Laboratory, Room 37-219, Cambridge, MA
Lee: Ph.D., MS 239-1, NASA Ames Research Center, Moffett Field, CA
Number of Pages: 11
Abstract: Quantitative models for the dynamics of the human vestibular system have been applied to the design and evaluation of flight simulator platform motion. An optimal simulator motion control algorithm has been generated to minimize the vector difference between perceived spatial orientation estimated in flight and in simulation. The motion controller has been implemented on the motion system of the Vertical Motion Simulator at NASA Ames Research Center and evaluated experimentally through measurement of

pilot performance and subjective rating during VTOL aircraft simulation. In general, pilot performance in a longitudinal tracking task (formation flight) did not appear to be sensitive to variations in platform motion condition as long as motion was present. However, pilot compensation required to perform the flight tasks, as reflected in Cooper-Harper ratings of vehicle handling qualities and the direct assessment of motion fidelity by means of a rating scale designed for this purpose, were sensitive to motion controller design. Platform motion generated with the optimal motion controller was found to be generally equivalent to that generated by conventional linear crossfeed washout.
The vestibular models have been used to evaluate the motion fidelity of transport category aircraft (Boeing 727) simulation in a pilot performance and simulator acceptability study at the Man-Vehicle Systems Research Facility at NASA Ames Research Center. Eighteen airline pilots, currently flying the B-727, were given a series of flight scenarios in the simulator under various conditions of simulator motion. The scenarios were chosen to reflect the flight maneuvers that these pilots might expect to be given during a routine pilot proficiency check. Pilot performance and subjective rating of simulator fidelity was relatively insensitive to motion condition, despite large differences in the amplitude of motion provided. This lack of sensitivity may be explained by means of the vestibular models, which predict little difference in the modeled motion sensations of the pilots when different motion conditions are imposed.
URL: http://stinet.dtic.mil/oai/oai?verb=getRecord&metadataPrefix=html&identifier=ADA202492

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Reference Type: Product Data Sheet
Author: CAE
Title: CAE True Environment
Abstract: Providing a more realistic training experience for pilots and a more effective training tool for instructors, CAE True™ Environment adds automated air traffic control (ATC) simulation and representative air and ground traffic to CAE's complete portfolio of simulation products. CAE has incorporated technology developed by Adacel for its ATC simulators to provide high traffic volume linked to realistic and context-specific voice communications based on speech recognition and text-to-speech technology. CAE True Environment ensures that what the pilots say and hear is fully correlated with what they see, making the training experience more immersive and realistic. CAE True Environment will improve quality of training and will meet emerging regulatory requirements for ATC environment simulation in flight simulators.
URL: http://www.cae.com/en/sim.products/_pdf/datasheet.cae.true.environment.pdf

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Reference Type: Conference Paper
Author: Calhoun, G.; Valencia, G.; Furness III, T. A.
Year: 1987
Title: Three-dimensional auditory simulation for crew station design/evaluation
Conference Name: Human Factors Society 31st Annual Meeting
Author's Title and Affiliation: Armstrong Aerospace Medical Research Laboratory, Wright-Patterson Air Force Base, Dayton, OH 45433-6573
Number of Pages: 5
Abstract: A three-dimensional (3-D) auditory display can increase the pilot's situational awareness without requiring visual fixation. When visual acquisition is required the directional sound can give the pilot a more rapid cue to aim the eyes or head. In order to determine the utility and performance of a 3-D auditory display for cockpit applications, a method for generating 3-D auditory cues is required for simulation. Two laboratory systems are described which create, from monaural stimuli, binaural stimuli which can be perceived as localized and stabilized in space, regardless of the listener's head position. Additionally, preliminary results of the localization performance with one approach are presented.

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Reference Type: Conference Paper
Author: Callantine, T. J.; Palmer, E. A.
Year: 2003
Title: Fast-time simulation studies of terminal-area spacing and merging concepts
Conference Name: 22nd AIAA/IEEE Digital Avionics Systems Conference
Conference Location: Indianapolis, Indiana
Publisher: Institute of Electrical and Electronics Engineers (IEEE)
Author's Title and Affiliation: Todd J. Callantine: San Jose State University
Everett A. Palmer: NASA Ames Research Center, Moffett Field, CA
Number of Pages: 8
Keywords: air-traffic-control, air-transportation, airport-operations, aviation, flight-simulators, human-factors-engineering, merging-control, Monte-Carlo-method, spacing
Abstract: This paper examines fast-time simulation that is designed to complement real time human-in-the-loop simulations. Presented is preliminary fast-time simulation as designed for TRACON spacing and merging concepts. These simulations allow a variety of experimental conditions to be varied via Monte Carlo method.

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Reference Type: Journal Article
Author: Callender, Mark N.
Year: 2008
Title: Transfer and cost effectiveness as guides to simluator/flight training device use
Journal: Collegiate Aviation Review
Volume: 26
Issue: 1
Pages: 28-32
Number of Pages: 5
Accession Number: 01114055
Keywords: cost effectiveness, education and training methods, flight simulators, flight training, training simulators
Abstract: As fuel prices climb and aircraft operating expenses follow suit, the training costs incurred by aviation students continue to rise. Responsible aviation programs must seek ways to provide safe and effective training while minimizing their students' training costs. To accomplish this, many aviation programs utilize flight simulation of some form as a complement to training in the aircraft. Simulation can be offered at greatly reduced per hour costs when compared to the aircraft, and as studies have shown, provides positive transfer of training from the simulated environment to the aircraft. Positive transfer of training implies that students will benefit from training in the simulated environment. This is only the case when the transfer effectiveness ratio (TER) is above a given value. It is the aim of this paper to demonstrate a method of evaluating the cost effectiveness of a training device by using the TER and the cost effectiveness ratio. By using these tools, the use of simulation will be of maximum benefit, i.e. reduced training costs, to aviation programs and their students.

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Reference Type: Web Page
Author: Calspan Flight Research Group
Year: 2005
Title: Airborne simulation
Series Editor: Calspan Corporation
City: Buffalo, NY
Access Year: 2006
Access Date: February 7
Description: Overview of airborne simulation and Calspan operated variable stability aircraft
Keywords: in-flight simulation, upset recovery training (URT)
Abstract: Airborne simulation, also known as in-flight simulation (IFS), provides a realistic replication of the flight and flying qualities of an aircraft, short of flying the actual aircraft. Airborne simulation is one of the key the [sic] development process for any new aircraft.
URL: Overview: http://www.calspan.com/airborne.htm
Calspan operated variable stability aircraft: http://www.calspan.com/variable.htm

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Reference Type: Conference Proceedings
Author: Carbaugh, Dave
Year of Conference: 2008
Title: Simulator upset recovery training and issues
Conference Name: AIAA Modeling and Simulation technologies Conference
Conference Location: Honolulu, HI
Publisher: American Institute of Aeronautics and Astronautics (AIAA)
Date: August 18-21
Electronic Resource Number: AIAA-2008-6866
Author's Title and Affiliation: The Boeing Company, Seattle, WA
Number of Pages: 3
Keywords: upset recovery training (URT), Upset Recovery Training Aid

Abstract: This presentation covers Airplane Upset Recovery Training from one airplane manufacturer's perspective from 1995 to 2008. The following items will be discussed in detail: the reasons for developing the Upset Recovery Training Aid, related accident history, reasons for recommending simulator training, and simulator fidelity. Early misunderstandings and difficulties in training students will be explained as well as the various methods used to improve training. A review of the recommended training scenarios will be argued. This presentation will discuss the tradeoffs that were made in using simulator presets as compared to manual upset entries. The reasons why the training aid was revised in 2004 will be explained as well as instructor difficulty in assessing Alpha and Beta limits. Lastly I will discuss the results of a human factors study of the performance of students as Upset Recovery training was introduced into the manufacturer's core curriculum.

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Reference Type: Report
Author: Cardosi, K.M.; Bürki-Cohen, J.; Boole, P.W.; Hourihan, J.; Mengert, P.; DiSario, R.
Year: 1992
Title: Controller response to conflict resolution advisory
City: Washington, DC
Report Number: DOT/FAA/NA-92/2

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Reference Type: Conference Paper
Author: Cardullo, Frank
Year: 1999
Title: Fundamentals of simulation
Conference Name: The Fifteenth Annual Flight and Ground Vehicle Simulation Update
Conference Location: State University of New York at Binghamton
Date: January 11-15
Author's Title and Affiliation: Professor, State University of New York at Binghamton
Number of Pages: 18

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Reference Type: Conference Paper
Author: Cardullo, Frank
Year: 1999
Title: Motion and force cueing II
Conference Name: The Fifteenth Annual Flight and Ground Vehicle Simulation Update
Conference Location: State University of New York at Binghamton
Date: January 11-15
Author's Title and Affiliation: State University of New York at Binghamton
Number of Pages: 90
Abstract: Motion and Force Cueing, II deals with the utilization of devices, which provide motion cueing by other than platform motion systems. All of these classes of systems are employed to supplement or fill the void not addressed by platform motion systems or to be used in place of those devices. There are portions of the motion environment experienced by pilots of aircraft that are not reproduced by platform motion systems. Hence these systems were developed to attempt to, "fill in the gaps".
There were three major classes of these systems in the past: G-Seats, Vibration Systems and High-G Augmentation Devices. The G-Seat was designed originally to provide sustained acceleration cues since platform motion onset cues are usually sustained for no more than 0.3 of a second. Vibrations systems were developed to provide the higher frequency vibration environment (usually 3-20 Hz) which for various reasons is not provided through platform motion systems. High-G Augmentation devices also extend the cueing capability of the platform motion system. In this case, these systems attempt to provide some of the physical effects, which occur in high-g flight and cannot be induced by platform motion systems. Some of these effects are a diminution of the visual field of view (tunnel vision), an increase in apparent

weight of the head and extremities, etc. The current thinking goes beyond the above to include primary motion cueing by devices other than platform motion systems.

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Reference Type: Conference Proceedings
Author: Cardullo, Frank M.
Year of Conference: 1991
Title: An assessment of the importance of motion cueing based on the relationship between simulated aircraft dynamics and pilot performance: A review of the literature
Conference Name: AIAA Flight Simulation Technologies Conference
Conference Location: New Orleans, LA
Publisher: American Institute of Aeronautics and Astronautics (AIAA)
Pages: 436-447
Electronic Resource Number: AIAA-91-2980-CP
Author's Title and Affiliation: Associate Professor, Mechanical Engineering, Associate Fellow AIAA, State University of New York, Binghamton, NY
Number of Pages: 12
Keywords: motion cueing, simulated aircraft dynamics, pilot performance, visual system, categories of motion
Abstract: This paper reviews a method of assessing the need for motion cueing based on the simulated aircraft flight dynamics environment. The flight environment is reduced into four categories: maneuvers which are largely open loop and low gain, high gain and closed loop with good visual, high gain and closed loop with poor visual and aircraft which are unstable; and assesses motion cueing requirements on that basis. Also reviewed is the motion cueing literature including both the results of performance studies and the transfer of training studies with the intent of establishing a determination of the relationship between the necessity of motion cueing and the task performed in the simulator.

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Reference Type: Newspaper Article
Reporter: Carey, Susan
Year: 1998
Title: Demand for pilots is soaring as old-timers take off
Newspaper: The Wall Street Journal
Pages: B1, B12
Issue Date: June 4
Author's Title and Affiliation: Staff Reporter of The Wall Street Journal
Number of Pages: 1

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Reference Type: Newspaper Article
Reporter: Carey, Susan; Michaels, Daniel
Year: 2002
Title: At some airlines, laptops replace pilots' 'brain bags'
Newspaper: The Wall Street Journal

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Reference Type: Conference Paper
Author: Carico, Dean
Year: 2007
Title: Revisiting aircraft flight simulator acceptance criteria
Conference Name: 18th Symposium of the Society for Flight Test Engineers European Chapter (SFTE EC)
Conference Location: Madrid, Spain
Publisher: Society for Flight Test Engineers
Date: June 11-13
Author's Title and Affiliation: AIR 5.1.6.11, Rotary Wing Ship Suitability, Naval Air Warfare Center Aircraft Division
Number of Pages: 11
Abstract: The cost and risk associated with flight operations using complex air vehicles in adverse environments demonstrate the importance of virtual flight test and training options. Pilots have used simulators for learning to fly and for proficiency training ever since Ed Link's "Blue Box" flight trainer was introduced in the mid 1930's. It was not until the 1970's that operational flight trainers (OFT) and weapon systems trainers (WST) were evaluated quantitatively by developmental flight test teams using standard aircraft evaluation techniques taught at the US Naval Test Pilot School. This process involved comparing aircraft data for a specified flight test condition to the simulator data for the same test condition. The simulator data are required to match flight test data for each specified maneuver within a certain specified percentage. Automatic flight fidelity evaluation options are built into most flight trainers, but the automatic options are based on matching flight test data within an arbitrary specified percentage or margin. The FAA evaluates their flight simulators in terms of levels B-D as a function of training requirements, where the model data are also compared to test data. Several studies have been performed that focused on simulator fidelity, including discussions of visual system, motion system, and aircraft model cues. Previous studies have demonstrated a difference in handling qualities and visual cue ratings when comparing actual aircraft maneuver task results to the same simulated task using the same pilots. Advanced aircraft simulator flight fidelity measures are needed to help better quantify the criteria required for Navy/Marine Corps operational flight trainer acceptance. It is important to relate the aircraft simulator flight fidelity measures to the increased emphasis on military flight operations quality assurance that focuses on improved readiness. It is also time to revisit aircraft flight simulator acceptance criteria taking advantage of available technology options. The US Navy has initiated a small business program that focuses on developing advanced aircraft simulator flight fidelity measures. The advanced simulator flight fidelity measures can be applied to different aircraft mission applications, including helicopter shipboard analysis. This paper reviews selected background information and discusses ongoing initiatives, focusing on rotorcraft, to improve simulator acceptance criteria.
Author Address: AIR 5.1.6.11, Rotary Wing Ship Suitability, Naval Air Warfare Center Aircraft Division, Patuxent River, MD 20670
dean.carico@navy.mil
(301) 342-1382

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Reference Type: Newspaper Article
Reporter: Carley, William M.
Year: 1999
Title: Pull up! United 747's near miss sparks a widespread review of pilot skills--Flight 863 skirted a mountain and buzzed residences in the San Francisco area--'They didn't do the basics'
Newspaper: The Wall Street Journal
Pages: A1, A8
Issue Date: March 19
Author's Title and Affiliation: Staff reporter of the Wall Street Journal
Number of Pages: 2
Keywords: upset recovery training (URT), United 747

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Reference Type: Book
Author: Carmona, Sergio; Nieto, Daniela
Year: 2008
Title: The specificity and sensitivity of uninhibited COR in labyrinthine-defective patients
Series Title: Annals of the New York Academy of Sciences
Series Volume: 1039
Number of Pages: 5
Keywords: cervico-ocular reflex, labyrinthine-defective patients, eye movements, nystagmus
Abstract: (From the chapter) The Cervico-ocular reflex (COR), which depends on propioceptive afferents from neck muscles to the vestibular nucleus, makes little contribution to the stabilization of gaze in humans. If labyrinthine function is lost because of disease, however, the COR may increase in gain and assume greater importance in generating compensatory eye rotations during natural head movements. We tested the COR, i.e., eye movement responses to rotation of the trunk about the earth fixed head (swinging test with fixed head STFH). If the vestibular function is intact, normally there should be no nystagmus. A total of 88 labyrinthine defective patients and 78 controls were studied. Of the 166 subjects evaluated, 88 presented some kind of alteration (either central or peripheral) and had STFH results showing "no inhibition" in 85 patients. Therefore, the STFH's sensibility is 96.6%. The remaining 3.4% were false negatives (i.e., pathology that could not be detected by the test). Of the 166 subjects evaluated, 78 had normal results and normal STFH. Therefore, STFH's specificity was 100%. We conclude that the study of the COR through STFH is a simple, useful, and clinically reliable test which should improve our knowledge of the interesting relationship between VOR and COR.

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Reference Type: Conference Paper
Author: Caro, P.
Year: 1977
Title: Platform motion and simulator training effectiveness
Conference Name: NTEC/Industry Conference
Publisher: Naval Training Equipment Center (NTEC)
Number of Pages: 6

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Reference Type: Report
Author: Caro, Paul
Year: 1979
Title: Some factors influencing transfer of simulator training
Institution: Human Resources Research Organization

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Reference Type: Journal Article
Author: Caro, Paul W.
Year: 1973
Title: Aircraft simulators and pilot training
Journal: Human Factors
Volume: 15
Issue: 6
Pages: 502-509
Author's Title and Affiliation: Human Resources Research Organization, Fort Rucker, AL
Keywords: aircraft pilots, aviation technology, educational programs, flight training, simulated environment, simulation, skill development, student projects, teaching methods, training laboratories, training methods, transfer of training

Abstract: Flight simulators are built as realistically as possible, presumably to enhance their training value. Yet, their training value is determined by the way they are used. Traditionally, simulators have been less important for training than have aircraft, but they are currently emerging as primary pilot training vehicles. This new emphasis is an outgrowth of systems engineering of flight training programs, and a characteristic of the resultant training is the employment of techniques developed through applied research in a variety of training settings. These techniques include functional context training, minimizing over-training, effective utilization of personnel, use of incentive awards, peer training, and objective performance measurement. Programs employing these and other techniques, with training equipment ranging from highly-realistic simulators to reduced-scale paper mockups, have resulted in impressive transfer of training. The conclusion is drawn that a proper training program is essential to realizing the potential training value of a device, regardless of its realism.

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Reference Type: Report
Author: Caro, Paul W.
Year: 1977
Title: Some factors influencing Air Force simulator training effectiveness
Date: March
Type: Technical Report
Report Number: HumRRO-TR-77-2
Author's Title and Affiliation: Seville Research Corporation, 400 Plaza Building, Pensacola, FL 32505
Number of Pages: 104
Keywords: aircraft simulation, simulators, simulator training, training device, training effectiveness, experimental design, simulator effectiveness, motion, fidelity, visual display, trainee characteristics, attitude, expectation, training
Abstract: A study of US Air Force simulator training was conducted to identify factors that influence the effectiveness of such training and to learn how its effectiveness is being determined. The research consisted of a survey of ten representative Air Force simulator training programs and a review of the simulator training research literature. A number of suspected or potential factors influencing simulator training effectiveness were identified. These factors include simulator design for training, visual display fidelity, platform motion system fidelity, handling characteristics, training program features, trainee and instructor characteristics, and attitudes and expectations toward simulator training. The discussion of each factor reviews relevant literature and Air Force simulator design features and training practices. Ten simulator training effectiveness study design models were identified. Efforts by the Air Force to validate the simulator training activities surveyed are described in relation to these ten models. It was found that the programs surveyed had not been subjected to formal evaluation studies that would establish their training effectiveness in quantitative terms. Therefore, the influence of factors identified during the survey upon such training could only be hypothesized. Recommendations were made concerning research and administrative action that could enhance future simulator training effectiveness.

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Reference Type: Journal Article
Author: Caro, P. W.
Year: 1979
Title: The relationship between flight simulator motion and training requirements
Journal: Human Factors
Volume: 21
Issue: 4
Pages: 493-501
Author's Title and Affiliation: Seville Research Corporation, Pensacola, FL
Number of Pages: 9
Abstract: Flight simulator motion has been demonstrated to affect performance in the simulator, but recent transfer of training studies have failed to demonstrate an effect upon in-flight performance. However, these transfer studies examined the effects of motion in experimental designs that did not

permit a dependency relationship to be established between the characteristics of the motion simulated and the training objectives or the performance measured. Another investigator has suggested that motion cues which occur in flight can be dichotomized as maneuver and disturbance cues, i.e., as resulting from pilot control action or from external forces. This paper examines each type cue and relates it analytically to training requirements. The need to establish such relationships in simulator design is emphasized. Future transfer studies should examine specific training objectives that can be expected to be affected by motion.

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Reference Type: Report
Author: Caro, Paul W.
Year: 1983
Title: Flight crew training technology--A review
Secondary Author: Lee, Alfred T.; Lauber, John K.
Secondary Title: Flight Training Technology for Regional/Commuter Airline Operation
Place Published: Moffett Field, CA
Publisher: National Aeronautics and Space Administration (NASA)
Author's Title and Affiliation: Seville Training Systems
Recipient's Title and Affiliation: NASA Ames Research Center, Moffett Field, CA 94035
Abstract: (from first page) This paper devotes a good bit of attention to simulators and other training equipment, but the most important message it contains is that pilot training is a process that is not dependent upon costly training equipment. Such equipment may be an important factor in making the training process easier to administer and control, but the single most important factor in efficient and cost effective training is the training process, that is, the way in which equipment and training resources are used to present information and cues, and to provide and reinforce practice.
URL: http://hdl.handle.net/2060/19850009701

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Reference Type: Report
Author: Carr, P.C.; McKissick, B. T.
Year: 1988
Title: Analysis procedures and subjective flight results of a simulator validation and cue fidelity experiment
Institution: NASA
Pages: 1-28
Date: July
Type: Technical Memorandum
Report Number: NASA-TM-88270
Author's Title and Affiliation: Peter C. Carr: Ames Research Center, Dryden Flight Research Facility, Edwards, CA
Recipient's Title and Affiliation: Burnell T. McKissick: Langley Research center, Hampton, VA
Number of Pages: 29
Keywords: cues, flight simulators, flight tests, pilot performance, proving
Abstract: A joint experiment to investigate simulator validation and cue fidelity was conducted by the Dryden Flight Research Facility of NASA Ames Research Center (Ames-Dryden) and NASA Langley Research Center. The primary objective was to validate the use of a closed-loop pilot-vehicle mathematical model as an analytical tool for optimizing the tradeoff between simulator fidelity requirements and simulator cost. The validation process includes comparing model predictions with simulation and flight test results to evaluate various hypotheses for differences in motion and visual cues and information transfer. A group of five pilots flew air-to-air tracking maneuvers in the Langley differential maneuvering simulator and visual motion simulator and in an F-14 aircraft at Ames-Dryden. The simulators used motion and visual cueing devices including a g-seat, a helmet loader, wide field-of-view horizon, and a motion base platform.
URL: http://www.nasa.gov/centers/dryden/pdf/88103main_H-1371.pdf

Reference Type: Report
Author: Carretta, Thomas R.; Dunlap, Ronald D.
Year: 1998
Title: Transfer of training effectiveness in flight simulation: 1986-1997
Institution: United States Air Force Research Laboratory
Date: September
Report Number: AFRL-HE-AZ-TR-1998-0078
Author's Title and Affiliation: Carretta: Training Effectiveness Branch, Warfighter Training Research Division, 7909 Lindbergh Drive, Brooks AFB, TX 78235-5352
Dunlap: Air Warrior Training Branch, Warfighter Training Research Division, 6001 South Power Road, Bldg. 558, Mesa AZ 85206-0904
Number of Pages: 17
Keywords: flight simulation, flight simulator, simulation-based training, simulator effectiveness, simulator transfer of training, training effectiveness, transfer of training
Abstract: The purpose of this report was to review recent studies regarding the effectiveness of flight simulators as augmentation for "hands-on" flying training. Simulation-based training has been proposed to reduce costs, extend aircraft life, maintain flying proficiency, and provide more effective training, especially in areas difficult to train in operational aircraft. A review of the literature from 1986 to 1997 identified 67 articles, conference papers, and technical reports regarding simulator flying training and transfer. Of these, only 13 were related directly to transfer of training from the simulator to the aircraft. Studies of simulator effectiveness for training landing skills constituted a majority of the transfer studies, although a few examined other flying skills such as radial bombing accuracy and instrument and flight control. Results indicate that simulators are useful for training landing skills, bombing accuracy, and instrument and flight control. Generally, as the number of simulated sorties increases, performance improves, but this gain levels off after approximately 25 missions. Further, several studies indicate that successful transfer may not require high-fidelity simulators or whole-task training, thus reducing simulator development costs. Evaluation of this literature is difficult for many reasons. Typically, researchers fail to report sufficient detail regarding research methods, training characteristics, and simulator fidelity. In addition to these methodological concerns, there is a lack of true simulator-to-aircraft transfer studies involving complex pilot skills. This may be due to problems such as inadequate simulator design, cost, and availability, and access to simulators in operational flying units. Future directions in simulator transfer of training are discussed.

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Reference Type: Report
Author: Casali, John G.; Frank, Lawrence H.
Year: 1986
Title: Perceptual distortion and its consequences in vehicular simulation: Basic theory and incidence of simulator sickness
City: Washington, D.C.
Institution: Transportation Research Board
Report Number: Transportation Research Record 1059
Author's Title and Affiliation: Human Factors Laboratory, Department of Industrial Engineering and Operations Research - Virginia Polytechnic Institute
Number of Pages: 9
Abstract: Simulator-induced sickness is a serious problem that can afflict the users of vehicular simulators including aircraft and driving devices. Operators and passengers in training and research simulators have experienced symptoms akin to those of motion sickness both during and following a simulator experience. In some cases, even several hours postexposure, aftereffects or flashbacks to the simulation environment may surface creating sudden disorientation in the individual. The simulator-sickness syndrome appears to be severe and frequent enough that it affects the utility of simulation and may create safety hazards for users. It has, therefore, recently received considerable attention by the human engineering community. This paper provides background information on the sickness problem; its theoretical underpinnings; and a brief, tabularized literature review specific to simulator sickness. All

available articles, reports, technical memoranda, and papers directly dealing with the problem of operator discomfort in vehicular simulators were obtained and selectively reviewed.

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Reference Type: Conference Paper
Author: Casali, John G.; Frank, Lawrence H.
Year: 1987
Title: Manifestation of visual/vestibular disruption in simulators: Severity and empirical measurement of symptomatology
Conference Name: Aerospace Medical Panel Symposium on Motion Cues in Flight Simulation and Simulator Induced Sickness
Conference Location: Brussels, Belgium
Publisher: Advisory Group for Aerospace Research and Development (AGARD)
Date: September 29
Author's Title and Affiliation: Casali: Ph.D., Virginia Polytechnic Institute and State University, Department of Industrial Engineering and Operations Research, Blacksburg, VA 24060
Frank: LCDR, MSC, USN, Ph.D., Human Factors and Operational Analysis Branch, Pacific Missile Test Center, Point Mugu, CA 93042-5000
Number of Pages: 18
Keywords: visual, vestibular disruption, simulator sickness, motion sickness, symptoms
Abstract: Reported incidence rates on vehicular simulator-induced sickness in operators is highly variable both within and between devices. Recent review of the literature indicates that documented incidence rates range from 0 to nearly 90% in flight devices and even higher in some driving devices. However, the severity of the simulator sickness problem is not adequately gauged by a simple count of those operators experiencing one or more physiologic symptoms. Instead, a battery of metrics is useful in identifying and properly assessing an induced state of simulator sickness. This is of particular importance with the recent thrust in empirical research toward determination of the effects of simulator design parameters, such as control loop delays, on operator sickness and performance. This paper reviews the symptomatology experienced by operators of flight and driving simulators. Drawing upon this review, dependent measures are recommended for use in simulator-sickness research including self-report forms, specific physiologic indices, postural equilibrium tests, performance tests and susceptibility prediction instruments. A tabular documentation of published research studies concerning simulator sickness is also provided, as is a discussion of the ramifications of the problem.
URL: http://stinet.dtic.mil/oai/oai?verb=getRecord&metadataPrefix=html&identifier=ADA202492

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Reference Type: Conference Paper
Author: Caudrey, Kip
Year: 2000
Title: The importance of matching technology advancement with training needs
Conference Name: Flight Simulation - The Next Decade
Conference Location: London, UK
Publisher: Royal Aeronautical Society (RAeS)
Date: May 10-12
Author's Title and Affiliation: Captain, Flight Safety Boeing Training International
Number of Pages: 7
Abstract: (Introduction) Advances made in Simulation Technology particularly during the past 10 years have been astonishing, primarily as a result of the massive increases in host and image generator computing power. Who would have guessed that it would now be possible to run a FFS including Motion & Visual from a laptop? However, few would disagree that although the fidelity of simulation and consequently training realism has been significantly improved during the same time period,

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Reference Type: Conference Paper
Author: Caudrey, Kip
Year: 2004
Title: Can flight simulators do everything?
Conference Name: SimTecT
Conference Location: Canberra, Australia
Publisher: Simulation Industry Association of Australia
Date: May 24-27
Author's Title and Affiliation: Captain Kip Caudrey, Director Simulator Evaluation & Standards, Alteon Training
Abstract: [from Introduction] Although this paper will still address the theme "Can Flight Simulators Do Everything" I have taken the liberty of making modifications to take into consideration that not everyone at this Conference is familiar with Flight Simulation nor the common acronyms. I have therefore spent more time focusing on the current status of our Industry and where we are going, to hopefully make the paper of greater interest to you.
URL: http://www.siaa.asn.au/simtect/2004/2004.htm

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Reference Type: Electronic Article
Author: Chamberlain, H. Dean
Year: 2001
Title: Qualified PC computer-based training devices take off
Periodical Title: FAA Aviation News
Volume: 2006
Issue: Sept. 6
Number of Pages: 4
Keywords: personal computers, flight training, flight simulators, personal computer-based aviation training devices (PCATD's)
Abstract: Describes the role of personal computer-based aviation training devices in pilot training.
Notes: As of 2/05/07, the web site was no longer accessible.
URL: http://avstop.com/Stories/Training.htm

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Reference Type: Web Page
Author: Chamberlain, H. Dean
Year: 2002
Title: Personal computer-based aviation training devices: Does yours meet FAA training requirements?
Access Year: 2006
Access Date: Sept. 6
Last Update Date: April 30, 2002
Type of Medium: Online article
Number of Pages: 8
Notes: On 2/05/07, the web page was no longer accessible.
URL: http://avstop.com/Technical/computer.html

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Reference Type: Report
Author: Chambers, Joseph R.
Year: 2003
Title: Concept to reality: Contributions of the NASA Langley Research Center to U.S. civil aircraft of the 1990s
Report Number: NASA SP-2003-4529
URL: http://oea.larc.nasa.gov/PAIS/Concept2Reality/index.html

Reference Type: Conference Paper
Author: Chambers, Walter S.
Year: 1999
Title: Visual simulation
Conference Name: The Fifteenth Annual Flight and Ground Vehicle Simulation Update
Conference Location: State University of New York at Binghamton
Date: January 11-15
Author's Title and Affiliation: Consultant, Future Technology, Inc.
Number of Pages: 13
Keywords: visual simulation, perception

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Reference Type: Conference Paper
Author: Chappelow, J. W.
Year: 1987
Title: Simulator sickness in the Royal Airforce: A survey
Conference Name: Aerospace Medical Panel Symposium on Motion Cues in Flight Simulation and Simulator Induced Sickness
Conference Location: Brussels, Belgium
Publisher: Advisory Group for Aerospace Research and Development (AGARD)
Date: September 29
Author's Title and Affiliation: RAP Institute of Aviation Medicine, Farnborough, Hampshire GU14 6SZ
Number of Pages: 11
Keywords: motion cues, simulator sickness
Abstract: A questionnaire survey was undertaken of pilots with experience of two air combat simulators. Two hundred and seventy one respondents completed questionnaires, some up to two years retrospectively and other immediately after a simulator session. There were, thus, four separate studies. The questionnaire sought information on the incidence of disequilibrium and other symptoms experienced in the simulator and after leaving it. The proportion of those suffering at least one symptom in the simulator varied between 50% and more than 90% across studies (53.5% overall). However, not all the symptoms reported were unequivocally ascribable to disequilibrium. The proportion of each sample reporting delayed symptoms was between 10% and 50% (13% overall). The effect on the respondent's motivation to use the simulator was negligible.
URL: http://stinet.dtic.mil/oai/oai?verb=getRecord&metadataPrefix=html&identifier=ADA202492

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Reference Type: Journal Article
Author: Cheung, B. S.; Howard, I.P.; Money, K. E.
Year: 1991
Title: Visually-induced sickness in normal and bilaterally labyrinthine-defective subjects
Journal: Aviation, Space, and Environmental Medicine
Volume: 62
Issue: 6
Pages: 527-531
ISSN: 0095-6562 (Print)
Number of Pages: 5
Accession Number: 1991-27789-001
Keywords: visual field rotation, motion sickness, 22-76 yr olds with vs without bilateral labyrinthine dysfunction
Abstract: Exposed a group of 9 Ss (aged 22–59 yrs) with no overt vestibular dysfunction and a group of 6 bilaterally labyrinthine-defective Ss (aged 34–76 yrs) to a visual field rotating about an Earth-horizontal axis (orthogonal to the gravity axis). The visual stimulus was provided by a 3-m diameter sphere with random dots rotating at 30, 45, and 60° per second about the stationary S's roll, pitch, and yaw axes. The S's head was positioned at the center of the sphere such that it experienced apparent motion in all 3

axes. In the normal group, symptoms of motion sickness were reported in 21 of 27 trials. When labyrinthine-defective Ss were exposed to the roll and pitch stimulus, no sickness symptoms were reported or observed. Results suggest that the vestibular system is necessary for sickness induced by moving visual fields.

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Reference Type: Electronic Article
Author: Chief Scientific and Technical Advisor for Human Factors (AAR-100)
Year: 2002
Title: Human factors newsletter #02-07
Volume: 2007
Issue: Feb. 5
Pages: Electronic newsletter
Number of Pages: 9
Abstract: New Feature: Research Report **-** *Realistic Radio Communications in Pilot Simulator Training*
URL: http://www.hf.faa.gov/docs/508/docs/newsletters/newsletter_0207.pdf
Access Date: April 12

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Reference Type: Conference Paper
Author: Chung, W.; Bürki-Cohen, J.; Go, T.H.
Year: 2004
Title: Task and vehicle dynamics based assessment of motion cueing requirements
Conference Name: AIAA Modeling and Simulation Technologies Conference
Conference Location: Providence, RI
Publisher: American Institute of Aeronautics and Astronautics (AIAA)
Date: August 16-19
Electronic Resource Number: AIAA 2004-5154
Author's Title and Affiliation: Chung: Aerospace Engineer, Spatial Technologies & Concept Division, Science Applications International Corporation, Hampton, VA
Bürki-Cohen: Engineering Psychologist, Operator Performance and Safety Analysis Division, USDOT/Volpe National Transportation Systems Center, Cambridge, MA
Go: Aerospace Research Engineer, Center for Transportation and Logistics, Massachusetts Institute of Technology, Cambridge, MA
Abstract: One significant difference between real and simulated flight on the ground are the stimuli or cues provided to the pilot. Due to physical and/or cost constraints, it is nearly impossible to match all the cues experienced in the air in ground-based simulators. Motion cues, in particular, are severely affected by the limits imposed on the ground, such as the extent of travel and the dynamics bandwidth. Researchers have been struggling for decades to develop a better understanding on how pilots' behavior and performance in the simulator are affected by these limitations, and to determine the motion-cueing requirements appropriate to the purposes of the simulation. It has been demonstrated that motion cues can affect pilot-vehicle performance and pilot behavior in ground-based simulators. However, whether motion cues affect behavior and performance appears to be a function of pilot task, vehicle dynamics, and cueing quality (of motion and other cues). The experimental design also greatly affects the validity (whether the data answer the research question) and reliability (whether the results can be replicated) of a study. This paper is developing a systematic approach to re-examine past studies in an effort to develop a comprehensive understanding of the effects of motion in ground-based flight simulators.
URL: http://www.volpe.dot.gov/hf/docs/aiaa451541c.pdf

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Reference Type: Conference Paper
Author: Chung, William; Gerdes, Ron; LaForce, Soren
Year: 1996
Title: Phase response requirements between cross-coupled motion axes for handling qualities research simulators
Conference Name: AIAA Flight Simulation Technologies Conference
Conference Location: San Diego, CA
Publisher: American Institute of Aeronautics and Astronautics (AIAA)
Date: July 29-31
Electronic Resource Number: AIAA 96-3478
Author's Title and Affiliation: NASA Ames Research Center, Moffett Field, CA
Number of Pages: 19
Abstract: An experiment was designed to study the effect of discrepancies between cross-coupled motion axes responses and to determine if phase response requirements for motion simulators is necessary for handling qualities research. Since the pilot is generally not located at the rotational center of a motion platform, this can produce distorted cues in a motion based flight simulator. For kinetically cross-coupled motion axes, such as roll and lateral, coordinated translational commands are required in order to compensate for induced linear accelerations caused by angular motion at the pilot station. The effect of phase response discrepancies between the roll and lateral cross-coupled motion axes was the focus of this experiment. A stability derivative model, which represents a fully decoupled aircraft response, was tailored to meet Level I rotorcraft handling qualities at low speed. The Vertical Motion Simulator, a gimbaled motion system at NASA Ames Research Center, provided the six degrees of freedom motion. The roll and lateral motion dynamics were modified to produce specific phase characteristics. This was required to study phase requirements between the roll angular acceleration and lateral specific force. Two low speed tasks, hover and side step, were used to evaluate the vehicle's handling qualities under three motion configurations and two visual delay configurations. The phase characteristics between the roll and lateral motion axes as well as the phase characteristics of the visual system were varied in the experiment. The test results indicated significant reduction in pilot workload and improved performance when the cross-coupled motion axes were in phase with each other and with the visual responses. A mismatch of phase response in the cross-coupled motion axes, up to 40 msec phase difference, led to increased pilot workload and poorer pilot handling qualities ratings in most instances. Due to a resulting large phase discrepancy between the visual and motion cues, the results also suggest that visual delay compensation had little or no effect on pilots' handling qualities ratings under the given test conditions.
URL: http://www.ffc.arc.nasa.gov/library_docs/tech_papers/AIAA%201996/Chung/1996_3478.pdf

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Reference Type: Journal Article
Author: Chung, William; Wang, William Y.
Year: 1988
Title: Evaluation of simulator motion characteristics based on AGARD-AR-144 procedures
Journal: Aerospace Simulation 1988
Pages: 177-188
Author's Title and Affiliation: Department of Simulation Programs, SYRE, Post Office Box 81, Moffett Field, CA 94035
Number of Pages: 12
Abstract: This paper presents the results of applying a set of motion evaluation procedures based on performance criteria developed by the North Atlantic Treaty Organization (NATO) Advisory Group for Aerospace Research and Development (AGARD) on the Vertical Motion Simulator (VMS) at Ames Research Center. The criteria being evaluated includes the describing function, operational limits and acceleration noise. The procedures include the development of a real-time operating system to generate the motion system drive commands and collect the response. The data analysis reveals the describing function and operational envelopes of the six motion axes, and the cross coupling between the motion axes.

Reference Type: Conference Proceedings
Author: Chung, William W.
Year of Conference: 2008
Title: A preliminary investigation of achievable motion cueing in ground-based flight simulators for upset recovery training maneuvers
Conference Name: AIAA Modeling and Simulation Technologies Conference
Conference Location: Honolulu, HI
Publisher: American Institute of Aeronautics and Astronautics (AIAA)
Date: August 18-21
Electronic Resource Number: AIAA 2008-6868
Author's Title and Affiliation: SAIC, Lexington Park, MD
Keywords: upset recovery training (URT)
Abstract: Using ground-based flight simulators for upset recovery training is appealing due to significant cost saving and safety enhancement. However, difficulty in obtaining acceptable simulation cueing, i.e., motion cues due to large amplitude of airplane's response, or lack of them, i.e., using fixed-base simulator, poses a question if positive transfer-of-training can be achieved on the ground providing aerodynamics database is improved to correctly address simulated airplane's response in abnormal flight conditions. This is a preliminary analysis to see if any motion related issues can be identified based on existing experience and known system constraints. Two mild upset and recovery maneuvers were analyzed based on different motion parameters to examine typical motion cueing fidelity issues in ground-based flight simulators.

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Reference Type: Conference Paper
Author: Chung, William W.; Schroeder, Jeffery A.
Year: 1997
Title: Visual and roll-lateral motion cueing synchronization requirements for motion-based flight simulations
Conference Name: American Helicopter Society 53rd Annual Forum
Conference Location: Virginia Beach, VA
Date: April 29-May 1
Author's Title and Affiliation: NASA Ames Research Center, Moffett Field, CA
Number of Pages: 13
Abstract: An investigation of flight simulation cueing synchronization requirements for the visual, roll motion, and lateral motion was conducted on the Vertical Motion Simulator (VMS) at NASA Ames Research Center. The unique displacement capability of the VMS was exploited by developing a piloted task such that the visual and motion cues matched closely for a baseline configuration. Pilots performed a lateral sidestep between two points 20 feet apart using a helicopter model designed to have satisfactory handling qualities. Since the VMS has in excess of 20 feet lateral travel, the task was simulated exactly. That is, the motion and visual cues had a one-to-one correspondence. Starting with the baseline simulation cueing configuration that had synchronous visual, roll, and lateral cues, time delays of 40 and 80 msec were introduced into the visual, roll, and lateral axes in a randomized matrix giving a total of 27 configurations. The baseline configuration was developed based on the current FAA helicopter simulator specifications for civil helicopter motion fidelity requirements, which has little objective data for its support. Six experienced test pilots from both government and industry rated all the configurations. Objective and subjective data were taken that included handling qualities ratings, motion fidelity ratings, and perceptions of synchronization. Initial analysis of the data indicate support for aspects of the current FAA specifications on civil helicopter motion fidelity requirements, with some additional preconditions. Based upon a statistical analysis of the data, recommendations are made for permissible cueing delays and asynchronization.

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Reference Type: Conference Paper
Author: Chung, William W.; Schroeder, Jeffery A.; Robinson, Doug J.
Year: 1997
Title: An initial evaluation of the effects of motion platform and drive characteristics
Conference Name: AIAA Modeling and Simulation Technologies Conference
Conference Location: New Orleans, LA
Publisher: American Institute of Aeronautics and Astronautics
Date: August 11-13
Electronic Resource Number: AIAA-1997-3503
Author's Title and Affiliation: William W. Chung and Jeffery A. Schroeder: Aerospace Engineer, NASA Ames Research Center, Moffett Field, CA
Doug J. Robinson: Research and Development Engineer, Lockheed Martin Skunk Works, Palmdale, CA
Number of Pages: 12
Abstract: Six motion cueing configurations were developed to investigate facility dependent effects on simulation fidelity. These configurations were tested on a large-amplitude motion-based flight simulator and, when possible, on a small amplitude hexapod flight simulator. On the large amplitude device, one configuration had no motion attenuation, and it served as the truth-case motion reference. Five other configurations were developed to represent a continuum of motion fidelity from high to low. Results from this investigation indicate that only the one-to-one motion configuration consistently reflected the predicted handling qualities ratings based on an existing handling qualities specification. It was also noted that reductions in motion fidelity can falsely improve handling qualities ratings. Non-trivial differences were measured between the facilities, and those differences are currently being investigated.

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Reference Type: Conference Paper
Author: Chung, William W.; Sweet, Barbara T.; Kaiser, Mary K.; Lewis, Emily
Year: 2003
Title: Visual cueing effects investigation for a hover task
Conference Name: AIAA Modeling and Simulation Technologies Conference
Conference Location: Austin, Texas
Publisher: AIAA
Date: August 11-14
Electronic Resource Number: AIAA 2003-5524
Abstract: In simulation, as in actual aircraft, pilots conduct their missions according to perceived vehicle performance and spatial orientation from out-the-window (OTW) information. Ground-based flight simulations rely upon computer-generated OTW visual scenes. The realism and fidelity of a specific OTW simulation therefore has a significant impact on mission effectiveness. This study investigates effects of three visual parameters of the computer-generated image system (field-of-view, collimation, and resolution) on a disturbance-rejection hovering task. Pilots' performance and workload were studied under the following conditions: collimated optics vs. non-collimated optics, wide field-of-view (FOV) vs. narrow FOV, and higher resolution vs. lower resolution. Subjects were instructed to maintain a station-keeping position during disturbances while piloting an uncoupled four degrees-of-freedom (DOF) helicopter model, which had a satisfactory rate-command system in pitch and roll axes and ideal heading and altitude hold. Display collimation and FOV were found to have significant effects on pilots' performance and their subjective perception of visual cueing quality.

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Reference Type: Conference Paper
Author: Chung, William W. Y.; Schroeder, Jeffery A.; Johnson, Walter W.
Year: 1997
Title: Effects of vehicle bandwidth and visual spatial-frequency on simulation cueing synchronization requirements
Conference Name: AIAA Atmospheric Flight Mechanics Conference
Conference Location: New Orleans, LA

Publisher: American Institute of Aeronautics and Astronautics (AIAA)
Electronic Resource Number: AIAA 97-3655
Author's Title and Affiliation: NASA Ames Research Center, Moffett, CA
Number of Pages: 15
Abstract: Results of a recent flight simulation study suggested criteria for visual and motion cueing synchronization, but only for one vehicle bandwidth and one visual scene. The purpose of the study reported here was to determine if those synchronization criteria may be generalized. In particular, a complete factorial design was used to examine the flight simulation effects of the following five experimental factors: visual time delay, roll motion time delay, lateral motion time delay, vehicle bandwidth, and visual spatial frequency. Five experimental test pilots completed the full experimental matrix. The results show that the more limited set of synchronization criteria generalize for the variations examined. That is, regardless of the vehicle bandwidths or the visual cueing spatial frequencies examined, the same synchronization criteria are applicable for the visual, roll, and lateral cues. Thus, the results add further confidence to the recently suggested criteria, which suggested three guidelines. First, roll and lateral motion cues should be synchronized, but if they cannot be, the asynchronization should be no more than 40 msec. Second, the visual and roll motion cues should also be synchronized, but if they cannot be, the asynchronization should also be no more than 40 msec. The synchronized roll and lateral motion cues can be allowed to lag, but should not lead the visual cues.

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Reference Type: Conference Paper
Author: Chung, W. Y.
Year: 2000
Title: A review of approaches to determine the effectiveness of ground-based flight simulation
Conference Name: AIAA Modeling and Simulation Technologies Conference
Conference Location: Denver, CO
Publisher: American Institute of Aeronautics and Astronautics (AIAA)
Date: August 14-17
Electronic Resource Number: AIAA 2000-4298
Author's Title and Affiliation: Logicon Information Systems & Services, Moffett Field, CA
Keywords: flight simulation, motion cueing, visual cueing, man/machine interaction
Abstract: A review of the current understanding of how key simulation cueing elements affect ground-based flight simulation has been conducted. The objectives are to develop a broad assessment of current approaches in determining simulator effectiveness and to identify future research directions. The review covers the visual cues and human/machine related topics. For visual cueing related issues, the review focuses on visual transport delay, resolution, scene content, and field-of-view. For human/machine interaction issues, the review focuses on human psychophysical characteristics, pilot models, and motion cueing criteria. Results and suggested future work from past investigations are summarized. Additional recommendations are presented.
URL: http://ffc.arc.nasa.gov/library_docs/tech_papers/AIAA%202000/Chung/2000_4298.pdf

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Reference Type: Report
Author: Civil Aviation Authority (CAA)
Year: 2006
Title: Safety Regulation Group Safety Plan 2006
Series Editor: Safety Regulation Group
Date: June 15
Keywords: loss of control, upset recovery training (URT)
Abstract: Loss-of-Control is the only type of accident that is not reducing in world-wide statistics. It most commonly occurs for non-technical reasons such as pilot's flight handling (especially in adverse weather), following a bird-strike or loading error that makes the aircraft difficult to control, aircraft icing, contaminated runways, or following a technical failure.
CAA action areas will include:

- Loading Error
- Flight Handling
- Aircraft Icing
- Contaminated Runways
- Technical Failure

URL: http://www.caa.co.uk/docs/33/SRG%20SAFETY%20PLAN%202006.PDF
Access Date: July 29, 2008

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Reference Type: Magazine Article
Author: Civil Aviation Training (CAT)
Year: 2007
Title: Air Deccan certification for Mechtronix FFT
Magazine: Journal for Civil Aviation Training (CAT)
Date: February 21
Type of Article: Online New Alert
Keywords: Air Deccan, full flight trainer (FFT), ATR, Mechtronix, dual certification
Abstract: Air Deccan has obtained dual certification for a Full Flight Trainer (FFT) manufactured by Mechtronix Systems.
Notes: On July 6, 2007, the web page was no longer available.
URL: http://www.halldale.com/News.aspx?Action=-617781463&ID=2e8b2eea-0007-45bb-9d38-9ca904e12853

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Reference Type: Journal Article
Author: Clark, Brant; Graybiel, Ashton
Year: 1967
Title: Egocentric localization of the visual horizontal in normal and labyrinthine-defective observers as a function of head and body tilt
Journal: Perception & Psychophysics
Volume: 2
Issue: 12-B
Pages: 609-611
ISSN: 0031-5117
Number of Pages: 3
Accession Number: 1968-06462-001
Keywords: egocentric localization, visual horizontal, head & body tilt, normal & labyrinthine-defective
Abstract: Perception of the visual horizontal by observers in five different combinations of head and body position was studied to determine the effect of 20-degree body tilts. Both normal and labyrinthine-defective observers made five settings to the visual horizontal for each condition using a goggle device which presented a collimated line of light to the right eye while the other eye was covered. The results showed no significant constant errors in the settings by either group, and it is suggested that the absence of the E-phenomenon was due primarily to adequate contact cues and kinesthetic cues. The data also makes it clear that vestibular information is not required for veridical perception of the visual horizontal under these experimental conditions.

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Reference Type: Journal Article
Author: Clark, B.; Graybiel, A.
Year: 1968
Title: Influence of contact cues on the perception of the oculogravic illusion
Journal: Acta Oto-Laryngologica
Volume: 65

Issue: 4
Pages: 373-380
ISSN: 0001-6489 (Print)
Electronic Resource Number: 10.3109/00016486809120978
Number of Pages: 8
Accession Number: 1970-05466-001
Keywords: oculogravic illusion perception, contact cues, synergistic vs antogonistic otolith-nonotolith information, labyrinthine defective men
Abstract: Measured 5 normal and 5 labyrinthine-defective (LD) men when they stood erect in a room while it was stationary, and when it was rotating. The procedure was designed to produce 2 situations for the normal men in which otolith and nonotolith information were synergistic and 3 others in which they were antagonistic. Perception of the visual horizontal during rotation was not systematically related to differences in head and body position nor were there significant differences between the normal and LD men. Results show that nonotolith information predominates.

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Reference Type: Conference Paper
Author: Clark, Carl C.
Year: 1962
Title: Human control performance and tolerance under severe complex wave form vibration and review of flight simulation
Conference Name: National Meeting on Manned Space Flight
Conference Location: St. Louis, MO
Date: April 30-May 2
Author's Title and Affiliation: Manager, Life Sciences Department, Martin Company, Baltimore 3, Maryland
Number of Pages: 176-194

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Reference Type: Web Page
Author: CNN
Year: 2000
Title: Concorde crash investigators focus on blown tire
Series Editor: transcripts, CNN.com
Series Title: Saturday Morning News
Access Year: 2006
Access Date: October 19
Description: Transcript of news aired July 29, 2000 9:24 AM ET
Keywords: Air France Concorde accident, blown tires, upset recovery training (URT)
Abstract: Debris from the wreckage of the Air France Concorde that crashed Tuesday in Paris is being examined in high-tech labs. Investigators know the jet blew a tire as it raced down the runway with a fiery trail. Now they're wondering if that blowout sparked a chain of events that resulted in a crash that killed 114 people.
URL: http://transcripts.cnn.com/TRANSCRIPTS/0007/29/smn.09.html

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Reference Type: Conference Paper
Author: Cohen, E.
Year: 1971
Title: How much motion is really needed in flight simulators?
Conference Name: Fourth International Simulation and Training Conference
Conference Location: Atlanta, GA
Publisher: Society of Automotive Engineers (SAE)

Author's Title and Affiliation: Link Div., The Singer Co.
Number of Pages: 6
Keywords: flight simulator, motion cues, degree-of-freedom
Abstract: Although the need for motion on flight simulators used for training is well accepted, there is a wide divergence of opinion on the kind and amount of motion required. This paper reviews the requirements for motion in each of the six degrees of freedom, and suggests the extent of motion desirable in each, as well as ways to exploit given motion system geometry.

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Reference Type: Book
Author: Cohen, J.
Year: 1988
Title: Statistical power analysis for the behavioral sciences
City: Hillsdale, NJ
Publisher: Erlbaum
Number of Pages: 1-552
Edition: 2
Original Publication: 1969
Reprint Edition: 1977

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Reference Type: Conference Proceedings
Author: Coiro, Domenico P.; De Marco, Agostino; Nicolosi, Fabrizio
Year of Conference: 2007
Title: A 6DOF flight simulation environment for general aviation aircraft with control loading reproduction
Conference Name: AIAA Modeling and Simulation Technologies Conference and Exhibit
Conference Location: Hilton Head, SC
Publisher: American Institute of Aeronautics and Astronautics (AIAA)
Date: August 20-23
Electronic Resource Number: AIAA-2007-6364
Author's Title and Affiliation: Coiro: Professor of Flight Mechanics
De Marco: Assistant Professor
Nicolosi: Assistant Professor
University of Naples Frederico II, Department of Aerospace Engineering, Naples, Italy
Abstract: This paper presents the main features of a six-degree-of-freedom (6DOF) flight simulation laboratory operated by the authors at the University of Naples.
The aim of the flight simulator is twofold: serving as a research tool for model characterization and for the investigation of flying qualities of very-light and ultra-light aircraft; and offering a training options [sic] to the pilots of such airplanes. For these reasons the simulator cockpit has been conceived and set up as a generic cabin of a general aviation aircraft.
The software suite that guides the various components of the system is based mainly on the features of FlightGear, an open-source flight simulation software. The simulation of aircraft motion, the cockpit instrument panel and flight controls, the outside scenery are all managed by a number of instances of FlightGear. All FlightGear instances are appropriately executed on different machines and communicate with each other via net protocols.
Simulations are also supported by two other software modules. The first one controls the 6DOF motion of the cockpit. The second module implements a force reproduction system on the cockpit controls. An overview of all these modules is given in the paper, along with the discussion of the advantages and potentialities given by the source code accessibility and the high configurability of FlightGear.
The force feedback model is particularly important to the purposes that this flight simulation facility has being [sic] designed for. To obtain an enhanced realism in piloting efforts, particular care has been taken to implement hinge moment equations in the simulation software. The result is a reliable closed-loop force-feedback system on all aircraft commands. Two useful and noteworthy generalizations have been implemented in this context: the effect of the mechanical linkage dynamics on the control surface motion

and the effects on the control displacement due to the mechanical friction and to the presence of springs. The geometric, mass, inertia characteristics of each control surface and the hinge moment coefficients are managed by the control loading software. All the details of this model are given in the paper.
Author Address: coiro@unina.it
agostino.demarco@unina.it
fabrizio.nicolosi@unina.it

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Reference Type: Journal Article
Author: Colavita, F. B.
Year: 1974
Title: Human sensory dominance
Journal: Perception and Psychophysics
Volume: 16
Issue: 2
Pages: 409-412
Author's Title and Affiliation: University of Pittsburgh
Number of Pages: 4
Abstract: Human Ss matched an auditory and a visual stimulus for subjective magnitude. Then each stimulus was used as a cue in a reaction time task. On occasions when both stimuli were presented simultaneously, Ss' responding was seen to be dominated by the visual stimulus. Of further interest was the finding that on some occasions of simultaneous light-tone presentation Ss were unaware that the tone had been presented. This apparent prepotency of the visual over the auditory stimulus was seen to persist across a variety of experimental conditions, which included giving Ss verbal instructions to respond to the tone when both stimuli were presented simultaneously.

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Reference Type: Magazine Article
Author: Collins, M. P.
Year: 2000
Title: The buzz about haptics: Zero-G research could lead to an enhanced attitude reference
Magazine: AOPA Pilot
Pages: 117-124
Date: August
Keywords: haptics, zero-G, motion sickness, disorientation
Abstract: Kristy Stokke's long blond hair flows haphazardly and her feet slowly slide above her head. The Massachusetts Institute of Technology senior is struggling to conduct an experiment in zero-G conditions. But Stokke is far away from MIT's campus labs. Far above them, too, for that matter. She's working in NASA's KC-135 microgravity research aircraft, officially named Weightless Wonder but better known as "The Vomit Comet." High above the Gulf of Mexico, the pilots of the four-engine jet follow a precise parabolic flight path, making a series of 45-degree climbs and descents that alternately subject the aircraft, its passengers, and their equipment to zero and positive 2 Gs. Stokke is too busy to think about motion sickness, a condition to which many of her fellow student researchers have succumbed. Instead, she's focused on her search for the answer to one question: Are there haptics in your future? An enthusiastic private pilot, Stokke sought to combine her interest in general aviation with the thesis that she had to complete as part of her undergraduate degree in mechanical engineering. Concerned about how easily VFR pilots can become disoriented when visual references are diminished, she hypothesized that disorientation can be reduced--and flight safety increased--by replacing the missing sensory cues. The result was Aeronautical Orientation Research Through Haptics--Study of Tactile Attitude Recovery, dubbed Northstar.

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Reference Type: Book Section

Author: Committee on Ship-Bridge Simulation Training; National Research Council
Year: 1996
Title: Use of simulation in training and licensing: Current state of practice
Book Title: Simulated Voyages: Using Simulation Technology to Train and License Mariners
City: Washington, D.C.
Publisher: The National Academies Press
Chapter: 2
Number of Pages: 5
Abstract: Because of recent trends in the marine industry toward smaller crew size, heightened public concern about marine safety and expectations for improvements, and changes in navigation and ship control technology, the integration of marine simulation into mariner training programs offers advantages and opportunities to improve human performance in a safe environment.

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Reference Type: Conference Paper
Author: Computer Multimedia Productions Corporation
Year: 1998
Title: Proceedings and exhibits CD-rom
Conference Name: 9th International Training & Education Conference (ITEC '98)
Conference Location: Lausanne, Switzerland
Date: April 28-30

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Reference Type: Magazine Article
Author: Condom, Pierre
Year: 1997
Title: Simulation and training on the move again
Magazine: Interavia
Date: April
Number of Pages: 4
Keywords: flight safety, Boeing
Abstract: The formation...of a new joint company by Boeing and FlightSafety International to offer world airlines full training services, coming after the acquisition of Reflectone by British Aerospace to offer reliable training services to its military customers - and especially to Hawk operators, are making observers think that things may once again be on the move.

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Reference Type: Report
Author: Conrad, B.; Schmidt, S. F.
Year: 1971
Title: A study of techniques for calculating motion drive signals for flight simulators
Institution: Analytical Mechanics Associates, Inc.
Pages: 1-69
Report Number: NASA CR-114345
Author's Title and Affiliation: Analytical Mechanics Associates, Inc., Mountain View, CA
Recipient's Title and Affiliation: NASA Ames Research Center, Moffett Field, CA
Number of Pages: 70
Abstract: (from INTRODUCTION)
One of the challenging and unsolved problems in applications of pilot-flight simulators is how the very restricted motion freedom of the translational and rotational drive systems can "best" be used to simulate realistic flying sensations. The problem is difficult to solve because the constraints of the motion drive systems (position limits, velocity limits, and acceleration limits) preclude duplication of the body rates and forces on the pilot of the real aircraft except in a few tasks like hovering, refueling, and formation flying.

As a result, the "best" motion is a compromise which attempts to provide the simulator test pilot with those flight sensations and motion "cues" that he needs while staying within the constraint barriers of the motion drive systems. The lack of knowledge on pilot needs, and the lack of a fundamental understanding of how such compromises in motion fidelity degrade the usefulness of the simulation test results, make the problem even more difficult.

In a previous study effort (Ref. 1), a number of empirical "rule-of-thumb" solutions to the problem were reviewed and documented. Also, a "heuristic" mathematical approach was given which tended to "explain" the empirical solutions. This approach was used to develop two promising washout circuits for the Ames All-Axis Motion Simulator. In order to evaluate these circuits, a "formation-type" flying task was conceived. In this task, the motion quality could be varied for near-perfect reproduction of real flight to a fixed-base (no motion) solution. The previous study effort terminated with the completion of an experimental program in which several pilots flew the formation-flying task for three different aircraft lateral handling characteristics with one-to-one motion and fixed-based (no motion). The results of that program showed that the task and simulated aircraft were such that one-to-one motion was very important to the simulator test pilots. The effect of motion was readily measured by rms calculations based on the pilot's ability to hold a tight formation. Hence, it was believed that the effects of washout circuit parameter variations (which affect the quality of motion) could be measured and the parameters optimized in an experimental investigation which used the formation-flying task.

The objectives of the study effort described in this report were as follows:

1. Develop an experimental test plan using the formation-flying task for the validation and refinement of the washout circuits described in Reference 1. The details of this plan are given in Section 2.
2. Execute the test plan in conjugation with NASA scientists and test pilots on the Ames simulation facilities. Some of the experimental results obtained in these tests are given in Section 3.
3. Analyze the experimental data in conjunction with NASA scientists, using pilot model identification methods. Difficulties encountered with these procedures are given in Section 4, along with a few preliminary results.
4. Develop FORTRAN IV washout programs for applications on the Ames All-Axis Simulator. Two such programs are described in the Appendix. Section 5 describes the use of these circuits.
5. Develop a questionnaire-type log to assist NASA personnel in documenting the experience obtained with the application of washout circuits to operational simulations. This log is presented in Section 6.

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Reference Type: Conference Paper
Author: Conrad, B.; Schmidt, S. F.; Douvillier, J. G.
Year: 1973
Title: Washout circuit design for multi-degrees-of-freedom moving base simulators
Conference Name: AIAA Visual and Motion Simulation Conference
Conference Location: Palo Alto, CA
Publisher: American Institute of Aeronautics and Astronautics (AIAA)
Date: September 10-12
Electronic Resource Number: AIAA 73-929
Author's Title and Affiliation: Bjorn Conrad and S. F. Schmidt: Analytical Mechanics Associates, Mountain View, CA
J. G. Douvillier: NASA Ames Research Center, Moffett Field, CA

Abstract: Piloted, moving-base simulators generally contain actuators and drive linkages with severe position, velocity, and/or acceleration limits. These limits prevent the motion drive trains from exactly reproducing the very general motion histories that may be solved for an aircraft computer simulation. This paper presents a mathematical framework for designing logic to accept motion-dependent parameters from a simulation, attenuating them ("washing them out"), and generating appropriately limited drive signals. This framework is sufficiently general to encompass six-degrees-of-freedom simulators with large motion capability. Emphasis is placed on preserving certain motion cue relations (such as those that would be observed in coordinated flight). Strategies for simulating side forces via tilts are shown. Finally, several specific circuits are shown. These circuits have proven to be readily adaptable to a variety of moving-base simulators.

Reference Type: Conference Proceedings
Author: Cook, Edward D.
Year of Conference: 2009
Title: Training and Simulation Regulatory Update: One FAAer's Hopeful, Optimistic View of the Future
Conference Name: World Aviation Training Symposium
Conference Location: Orlando, FL
Notes: This was a PowerPoint presentation given at the WATS April 2009 Conference in Orlando

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Reference Type: Conference Paper
Author: Cooper, George E.; Drinkwater, Fred J., III
Year: 1970
Title: Pilot assessment aspects of simulation
Conference Name: Simulation
Conference Location: Ames Research Center, Moffett Field, CA
Publisher: Advisory Group for Aerospace Research and Development (AGARD)
Date: March
Author's Title and Affiliation: NASA Ames Research Center, Moffett Field, CA 94035
Number of Pages: 16
Keywords: pilot assessment, simulation, validation, visual displays, pilot stress, motion
Abstract: This lead paper on the pilot assessment aspects of flight simulation discusses in greater detail some of the problems introduced in the AGARD Report 567, "The Use of Pilot Rating in the Evaluation of Aircraft Handling Qualities" (1). The important function of a lead paper on pilot assessment is to introduce the critical questions raised by pilots so they can be examined and discussed with the aim of developing solutions and improved understanding. Some answers are proposed that may in themselves be controversial and stimulate further discussions.
One major difficulty in the application and utilization of pilot assessment in simulation is that there are no simple black and white answers for many of our problems, and continuing communication between pilots and engineers is essential. This is not so difficult to understand when we realize that with simulation we are seeking answers with only part of the tools for the job, and we are using the human element, namely the pilot, to bridge the gap between simulation on one hand, and the final flight application on the other. It is important, therefore, that we involve the pilot as early as possible in developing a piloted simulation program.
In order to bring out the pilot's viewpoint, we have reviewed common pilot gripes and complaints arising from simulation experiences and selected a number of questions or problems that we believe focus discussion on areas of maximum interest and concern. We consider first the apparent primary concern of pilots participating in simulation work, and next the questions related to the pilots' actual participation in the planning and conduct of experiments, the simulation situation in terms of the facility being used, and the analysis and reporting of results.
Notes: Lead discussion by J. Pinet and Lt. C. A. Wheal, RN. Open discussion also included.

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Reference Type: Report
Author: Cooper, George E.; Harper, Robert P., Jr.
Year: 1969
Title: The use of pilot rating in the evaluation of aircraft handling qualities
City: Washington, DC
Institution: National Aeronautics and Space Administration (NASA)
Date: April
Type: Technical Note
Report Number: NASA TN D-5153
Author's Title and Affiliation: Cooper: NASA Ames Research Center
Harper: Cornell Aeronautical Laboratory
Number of Pages: 52

Abstract: Pilot rating scales and their use in assessing aircraft handling qualities are reviewed historically, and objections that have been raised to limitations of earlier scales are considered in the development of a revised scale. Terminology used in the evaluation of handling qualities is reviewed and new definitions are proposed to improve communication and international understanding. Of particular significance is the new definition of handling qualities, which emphasizes the importance of factors that influence the selection of a rating other than stability and control characteristics.
The experimental use of pilot rating is discussed in detail, with special attention devoted to (1) clarifying the difference between mission and task, (2) identifying what the rating applies to, (3) considering the pilot's assessment criteria, and (4) defining the simulation situation. The important elements of the report are then summarized in a suggested "Briefing Guide," designed for guidance in planning and executing handling qualities.
Notes: Some portions of this report:
*Summary--p. 1
*Introduction--pp. 1-2
*Early Rating Scales--pp. 7-8
*Revised Pilot Rating Scale--pp. 8-17
*Pilot Assessment Considerations--pp. 22-25
*Simulation Situation--pp. 25-29
*Appendix B: Briefing Guide and Rating Information for Handling Qualities Experiments--pp.34-39
*References--p. 52

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Reference Type: Conference Paper
Author: Cooper, J. C.; Rutherford, M. L.; McKinnon, G. M.
Year: 1985
Title: Digital control loading and motion: The final word?
Conference Name: Interservice/Industry Training, Simulation & Education (I/ITSEC) Conference
Conference Location: Montreal
Publisher: CAE Electronics Ltd.
Author's Title and Affiliation: Cooper: Group Leader, Control Loading, CAE Electronics Ltd., Montreal, Canada
Rutherford: Manager, Systems Engineering, CAE Electronics Ltd., Montreal, Canada
McKinnon: Director, R & D, CAE Electronics Ltd., Montreal, Canada
Number of Pages: 6
Abstract: This paper reviews the essential elements in effective load unit design and introduces a novel approach to digital control loading and motion with extensive performance and logistics benefits. Performance of the digital system is superior to modern analog systems. A 3-KHz iteration rate provides the ability to model non-linear characteristics which are difficult to reproduce cost-effectively in an analog model. Maintenance and sparing of the digital controller is simplified by the use of a minimum number of different card types with built-in automated diagnostics which locate failures at the board level. Updates and maintenance adjustments are performed through user-friendly software utilities, with rigid configuration control of the system's state via software backups.

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Reference Type: Conference Proceedings
Author: Correia Grácio, B. J. ; Wentink, M.; Groen, E.; Bles, W.
Year of Conference: 2009
Title: Subjective estimates of g-load in centrifuge-based simulation and applications for g-cueing in Desdemona
Conference Name: AIAA Modeling and Simulation Technologies Conference
Conference Location: Chicago, IL
Publisher: American Institute of Aeronautics and Astronautics (AIAA)
Pages: 1-8
Date: Aug. 10-13

Electronic Resource Number: AIAA-2009-5919
Author's Title and Affiliation: Correia Grácio, Wentink, & Groen: Researchers, Perception & Simulation, TNO Defense, Safety and Security, Soesterberg, The Netherlands
Bles: Senior Researcher, Perception & Simulation, TNO Defense, Safety and Security, Soesterberg, The Netherlands
Number of Pages: 8
Keywords: centrifuge, g-load, Desdemona
Abstract: In centrifuge simulators pilots experience the G-forces and fast G-onsets encountered in the real fighter aircraft. The motion cueing principle that drives these simulators is based on creating G-forces by increasing the centripetal force of the centrifuge through a rotation of the simulator arm. The centrifuge usually spins at a constant 1.4 G baseline G-level when the aircraft is level and stationary. Ideally, the motion cueing algorithm presents to pilots a G-vector that is equal to the real one both in direction and amplitude. This motion cueing principle assumes that the pilots perceive any deviation from the desired G-load. If this is not true, one could reduce the high angular accelerations/decelerations of the centrifuge arm since there is no need to reach the exact airplane G-load. This would then reduce the negative side-effects (like motion sickness) that come from the high angular accelerations/decelerations in short-radius centrifuges. We investigated the just noticeable differences (JND) in the perception of G-load magnitude. The study was conducted in the Desdemona research simulator where eleven subjects participated in the experiment. Subjects actively had to reproduce a G-load that was passively presented to them. Two G-loads were presented to the subjects (1.6 G and 1.8 G). Results showed that subjects have a better accuracy in reproducing the 1.6 G than the 1.8 G condition. This indicates that the JND in perceiving the magnitude of the G-load is related with the G-load intensity.

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Reference Type: Report
Author: Corwin, William H.; Sandry-Garza, Diane L.; Biferno, Michael H.; Boucek, George P., Jr.; Logan, Aileen L.; Jonsson, Jon E.; Metalis, Sam A.
Year: 1989
Title: Assessment of crew workload measurement methods, techniques and procedures. Volume I--Process, methods, and results
City: Dayton, OH
Institution: Cockpit Integration Directorate, Wright Research and Development Center, Air Force Systems Command, Wright-Patterson Air Force Base
Date: September
Type: Final Report
Report Number: WRDC-TR-89-7006 Volume I
Number of Pages: 237
Keywords: subjective measures, performance measures, physiological measures
Abstract: This report summarizes the work conducted as part of an FAA/U.S. Air Force sponsored contract (F33615-C-86-3600) "The Assessment of Crew Workload measurement Methods, Techniques, and Procedures." The primary goal of the contract was to identify assessment techniques which demonstrate evidence of validity and reliability and are suitable as measures of flightcrew workload for aircraft certification.
To use a workload assessment technique with confidence for the certification of an aircraft flightdeck, the validity and reliability of the technique must be well established. Validity is the capability of the assessment technique to measure the abstract construct it is proposed to measure. Reliability is the capability of the measure to produce the same results with repeated testing.
A comprehensive literature review was conducted to identify workload measures which have an empirical record of validity and reliability. All candidate workload assessment techniques had to be applicable for evaluating workload in an aircraft environment. Two workshops were conducted to bring together experts in the workload assessment field to determine candidate measures for simulation testing (aided by the literature search), and make recommendations for testing in a high fidelity simulation. Two separate simulation tests were conducted at the Man Vehicle System Research Facility at NASA-Ames Research Center using a Phase II B-727 motion-base simulator.

The process by which this contract was conducted allows us to make factual statements regarding the validity and reliability of workload measures. The findings of validity and reliability for the workload measures tested are repeatable as demonstrated by the replication of results in the second simulation study. The method employed in this contract allows for an audit trail of the process by which an assessment technique is determined to be valid and reliable. A summary of the steps completed for this contract includes:
a. Literature review and Fact Matrices
b. Workshop to gather expert agreement
c. Simulation testing
Workload measures which demonstrated evidence of validity and reliability in simulation testing includes:
a. In-flight and Post-flight subjective ratings (SWAT, NASA-TLX, and Bedford rating scales)
b. Heart rate, as measured by R-to-R wave interbeat Interval
c. Control Input Activity for the wheel (aileron) and column (elevator) during manual flight path control

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Reference Type: Conference Paper
Author: Cowdrey, D. A.
Year: 1985
Title: Advanced visuals in mission simulators
Conference Name: Flight Mechanics Panel Symposium on Flight Simulation
Conference Location: Cambridge, United Kingdom
Publisher: Advisory Group for Aerospace Research and Development (AGARD)
Date: September 30-October 3
Author's Title and Affiliation: Group Leader - Visual Applications, Singer Link-Miles Ltd, Dept 060, Churchill Industrial Estate, Lancing, W. Sussex BN15 8UE, United Kingdom
Number of Pages: 10
Keywords: visual, mission simulator, image generator, display systems, heat-mounted display, eye-tracked AOI
Abstract: Modern sophisticated full mission flight systems trainers are capable of accurate representation of the actual aircraft in many areas including handling, controls, systems, etc. The major area of inadequacy to date has been the inability to produce a satisfactory visual representation of the outside works. To produce an image to match that of the pilot's field-of-view at the required resolution is beyond the capabilities of conventional visual system technology. This paper describes various alternative techniques developed at the Link Flight Simulation Division of the Singer Company, based on an eye-enslaved area-of-interest (AOI) concept
Notes: Published in September 1986.

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Reference Type: Report
Author: Cowings, Patricia S.; Toscano, William B.; DeRoshia, Charles
Year: 1998
Title: An evaluation of the frequency and severity of motion sickness incidences in personnel within the Command and Control Vehicle (C2V)
Date: January
Type: Technical Memorandum
Report Number: A-98-09480
Author's Title and Affiliation: Cowings, DeRoshia: NASA Ames Research Center, Moffett Field, CA Toscano: University of California, Los Angeles, CA
Number of Pages: 28
Keywords: human performance, motion sickness, psychophysiology
Abstract: The purpose of this study was to assess the frequency and severity of motion sickness in personnel during a field exercise in the Command and Control Vehicle (C2V). This vehicle contains four workstations where military personnel are expected to perform command decisions in the field during combat conditions. Eight active duty military men (U.S. Army) at the Yuma Proving Grounds in Arizona

participated in this study. All subjects were given baseline performance tests while their physiological responses were monitored on the first day. On the second day of their participation, subjects rode in the C2V while their physiological responses and performance measures were recorded. Self-reports of motion sickness were also recorded. Results showed that only one subject experienced two incidences of emesis. However, seven out of eight subjects reported other motion sickness symptoms; most predominant was the report of drowsiness, which occurred a total of 19 times. Changes in physiological responses were observed relative to motion sickness symptoms reported and the different environmental conditions (i.e., level, hills, gravel) during the field exercise. Performance data showed an overall decrement during the C2V exercise. These findings suggest that malaise and severe drowsiness can potentially impact the operational efficiency of the C2V crew. It was concluded that conflicting sensory information from the subject's visual displays and movements of the vehicle during the field exercise significantly contributed to motion sickness symptoms. It was recommended that a second study be conducted to further evaluate the impact of seat position or orientation and C2V experience on motion sickness susceptibility. Further, it was recommended that an investigation be performed on behavioral methods for improving crew alertness, motivation, and performance and for reducing malaise.
Notes: Sponsoring organization: NASA

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Reference Type: Conference Proceedings
Author: Crider, Dennis
Year of Conference: 2008
Title: The need for upset training
Conference Name: AIAA Modeling and Simulation Technologies Conference
Conference Location: Honolulu, HI
Publisher: American Institute of Aeronautics and Astronautics (AIAA)
Date: August 18-21
Electronic Resource Number: AIAA 2008-6864
Author's Title and Affiliation: National Transportation Safety Board (NTSB), Washington, DC
Keywords: upset recovery training (URT)
Abstract: Several aviation accidents have occurred over the years, many in this decade, which have involved upsets from normal flight. Sometimes these upsets occurred slowly without the pilot noticing the departure until reaching an unusual attitude. Others occurred abruptly, such as those caused by a stall, whether early due to icing or other environmental factors, or at the normal point due to human action or inaction. Other abrupt departures have been caused by mechanical failures or environmental factors, such as aircraft wakes. Given the potentially serious consequences of such upsets, the ability to recover is an important part of pilot training. Accordingly, a comprehensive, well-conceived training program will necessarily address the various types of upset scenarios that may lead to accidents, the need to avoid negative transfer of training and, for accidents involving stalls, the need to accommodate simulator model aerodynamic data envelope limitations. Many, if not most, upsets remain within the aerodynamic data envelope such that current aerodynamic model limits would not be exceeded when these scenarios are simulated. Motion cueing is another issue for many upset training scenarios.

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Reference Type: Unpublished Work
Author: Crider, Dennis A.
Year: 2006
Title of Work: Training simulators and flight safety
Pages: 1-7
Type of Work: Paper
Author's Title and Affiliation: Chief Technical Advisor, Vehicle Simulation, National Transportation Safety Board, Washington, DC 20594
Number of Pages: 7
Keywords: flight simulator training, safety recommendations, negative training, flight envelope, upset recovery training (URT)

Abstract: (from first page of paper) The National Transportation Safety Board has long recognized the importance of simulator training to aviation safety and issued a simulator training safety recommendation in 1969, just 2 years after the Safety Board was created. At that time, the Board recommended to the FAA that "All maneuvers requiring simulated engine(s) out operation of aircraft close to the ground be conducted in simulator training devices where possible." This recommendation and others since recognize the fundamental fact that some types of training are safer to do in simulators where at most a crash results in a simulator reset rather than broken bones and bent metal. In the simulator, relatively uncommon but dangerous environmental factors, such as airframe icing and some atmospheric motions like windshear and aircraft wake encounters, are available at the touch of a button.
For example, pilots can routinely train through simulation of the 1985 Delta Airlines flight 191 Dallas/Fort Worth accident windshear.
Over the years, lessons learned from accident investigations have been integrated into the simulator training syllabus and general flight training simulator requirements. Windshear modeling and airframe icing are, for example, included in the Federal Aviation Administration (FAA) advisory circular (AC) 120-40B, Airplane Simulator Qualification. Other, more recent accident investigative feedback has been provided for incorporation into simulators through operational bulletins, specific ACs, and other guidance.
Although flight training simulators are wonderful tools for providing safer training and producing safer pilots, the Safety Board has on occasion seen cases where modeling is unrealistic, resulting in negative training. I believe that by requiring physics-based (that is, realistic) modeling, the ICAO 9625 International Working Group can reduce if not eliminate such negative simulator training in the future.
Presently, simulators are conformed and certified by comparing the simulator response to control inputs recorded for a set of maneuvers to the actual aircraft response to the same control inputs. These tests are conducted at conditions well within the normal flight envelope. No guidance presently exists on how to simulate and validate maneuvers outside the normal flight envelope or on how to simulate such occurrences as wake turbulence or icing encounters. The simulator operator or manufacturer is free to model these conditions as it sees fit. Unfortunately, the absence of requirements has caused some problems.

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Reference Type: Journal Article
Author: Crider, Dennis A.
Year: 2010
Title: Upset recovery training
Journal: Aeronautical Journal
Volume: 114
Issue: 1159
Date: September
Author's Title and Affiliation: Dennis A. Crider, Chief Technical Advisor, Vehicle Simulation, National Transportation Safety Board (NTSB)
Number of Pages: 17
Abstract: Loss-of-control upsets during normal flight are one of the most common types of aircraft accidents. The study of these accidents reveals common characteristics that suggest areas where training can positively impact the safety of flight.
A variety of causes lead to in-flight upsets, including mechanical failures, wakes, spatial disorientation, and stalls. While most upsets occur fairly rapidly, those resulting from spatial disorientation often occur more slowly. Spatial disorientation upsets in roll have occurred when the flight crew was distracted or thought that the autopilot was on when it was off. Spatial disorientation accidents in pitch also have occurred due to the somatogravic pitch-up illusion. Upsets due to mechanical failure, wakes, and spatial disorientation most often occur at unstalled conditions well within the aerodynamic flight data envelope. However, improper responses can cause the aircraft to enter a stall after the initial upset or, if the initial upset was due to a stall, continue in a stall. Such improper responses include not putting the column forward enough, or pulling back even though this makes the situation worse. These responses may be due to an over-emphasis during training on recovering with "minimum loss of height"; hardly relevant where hitting the ground is not a problem. Nearer to the ground, improper responses could be due to the

visual cue that has been called "ground rush". At all altitudes, it is crucial to train pilots to reduce angle of attack as a primary part of upset recovery at, or near, stall.

Aircrews are likely to rely on stall protection systems to protect against loss-of-control upsets due to stalls. However, stalls due to airframe icing usually occur at a significantly lower angle-of-attack than stalls that occur with an uncontaminated airframe and, as a result, may occur before the stall protection system reaches the trigger angle-of-attack. Stalls may also occur without warning for uncontaminated airframes when the stall protection system fails. Such cases demonstrate the importance of recognizing the stall cues and implementing positive sustained recovery controls promptly, without cues from the stall warning system. Even when the stall warning system does provide warnings, accident/incident history shows that crews may ignore stall warnings and either maintain nose-up controls or fail to execute and sustain positive recovery controls. Accident history also suggests that flight crews can be reluctant to move the pitch control in the nose-down direction when they are stalled and the aircraft is pitched nose low and/or significantly banked.

In each of these scenarios, training might prepare pilots to respond correctly. This paper will present short case studies of several aircraft upset accidents and incidents and explore common threads that suggest areas of training that could prevent future upset accidents and incidents.

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Reference Type: Report
Author: Criel, Todd M.; Wyatt, Fred V.
Year: 1988
Title: Sandia National Laboratories: Flight simulation facilities
City: Albuquerque, NM
Institution: Sandia National Laboratories
Date: May
Report Number: SAND87-2034 . UC-13
Author's Title and Affiliation: Exploratory Systems Development Division, Wyatt, Aerospace Projects Division
Number of Pages: 14
Abstract: Flight simulation computer facilities and motion simulator facilities at Sandia National Laboratories include an AD-10, an AD-100 (both real time digital simulation computers), two AD-5s (analog computers), a VAX 11/780 (a digital mainframe), a PDP 11/60 (a digital computer), and a Carco S-450R-3/R three axis motion simulator. This report describes the current equipment.

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Reference Type: Magazine Article
Author: Croft, John
Year: 2002
Title: Inflight upset training puts muscle behind the book work
Magazine: Aviation Week & Space Technology
Date: August 26
Author's Title and Affiliation: Buffalo, NY
Keywords: in-flight simulation, upset recovery training (URT)

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Reference Type: Electronic Article
Author: Croft, John W.
Year: 2003
Title: Refuse-to-crash: NASA tackles loss of control
Periodical Title: Aerospace America
Issue: March
Keywords: loss of control, upset recovery training (URT)
Abstract: Technologies under study at NASA will alert pilots of loss of control in time to take action—or take action for them.

URL: http://www.aiaa.org/aerospace/Article.cfm?issuetocid=322&ArchiveIssueID=36
Access Date: June 15, 2007

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Reference Type: Report
Author: Cross, Kenneth D.
Year: 1992
Title: Training effectiveness assessment: Methodological problems and issues
City: Moffett Field, CA
Institution: National Aeronautics and Space Administration (NASA), Ames Research Center
Date: April
Report Number: NTIS No. N93-30684
Keywords: flight simulators, helicopters, pilot performance, pilot training, training evaluation, economic factors, effectiveness
Abstract: The US military uses a large number of simulators to train and sustain the flying skills of helicopter pilots. Despite the enormous resources required to purchase, maintain, and use these simulators, little effort has been expended in assessing their training effectiveness. One reason for this is the lack of an evaluation methodology that yields comprehensive and valid data at a practical cost. Some of these methodological problems and issues that arise in assessing simulator training effectiveness, as well as problems with the classical transfer-of-learning paradigm were discussed.
Notes: In NASA/FAA simulator workshop p. 77-90.

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Reference Type: Report
Author: Cross, Kenneth D.; Gainer, Charles A.
Year: 1984-1985
Title: An enumeration of research to determine the optimal design and use of army flight training simulators
City: Fort Rucker, AL
Institution: Anacapa Sciences, Inc.
Date: October
Type: Final Report
Report Number: ARI Technical Report 763
(performing organization report number) ASI479-066-85
Author's Title and Affiliation: Anacapa Sciences, Inc, P.O. Box 489, Fort Rucker, AL 36362
Recipient's Title and Affiliation: U.S. Army Research Institute for the Behavioral and Social Sciences, 5001 Eisenhower Avenue, Alexandria, VA 22333
Keywords: army flight simulator research requirements, helicopter pilot training, transfer of training, backward transfer, flight simulator fidelity requirements, training device characteristics, flying skill acquisition, flying skill sustainment, training device requirements, training effectiveness assessment
Abstract: This document lists and describes research the authors judged necessary to determine the optimal design and use of Army flight training simulators. Two major lines of research are described; the first addresses the design fidelity issue. Specifically, research is described that is judged necessary to determine the most cost- and training-effective level of fidelity for four simulator components: the visual system, the motion systems, the math models that determine the handling qualities of the flight simulator, and the cockpit displays and controls. The purpose of the second line of research is to determine how best to use production simulators that have been or are soon to be acquired by the Army. This line of research focuses primarily on the use of production simulators for field unit aviators who have completed institutional training and have been assigned to an operational field unit. However, the second line of research addresses some issues associated with the use of flight simulators for institutional training at the U.S. Army Aviation Center received before the aviator's first assignment to an operational unit.
This document was prepared to serve as a vehicle for initiating meaningful dialogue among the agencies and personnel who share responsibility for optimizing the benefits of the Army's Synthetic Flight Training System (SFTS) program; it has not been officially endorsed by any Army agency.

Reference Type: Report
Author: Cross, Kenneth D. ; Szabo, Sandra M. (Eds.)
Year: 1986
Title: Human factors research in aircrew performance and training: Final summary report
City: Fort Rucker, AL
Institution: ARI Field Unit
Date: November
Type: Final Summary Report
Report Number: ARI Research Note 86-94
Author's Title and Affiliation: Anacapa Sciences, Inc., P.O. Box 489, Fort Rucker, AL 36362
Number of Pages: 214
Keywords: Army aviator training requirements: active duty aviators, individual ready reserve aviators, National Guard aviators, reserve unit aviators, flight surgeons; Army retention/attrition: separation questionnaire, attrition causes, retention causes; retention of helicopter flying skills; maintenance of flying skills: flying time required, practice iteration required; Army aviator training: simulator, aircraft, time, night, team, unit; Army aviator selection test development/validation: aptitudes, abilities, task/ability analysis; Army aviator performance measurement/evaluation: in simulators, in aircraft, in training, in research, consensual decision making, aviation resource management survey; Army helicopter workstation design: mission analysis, task analysis, function allocation, workload prediction, workload measurement, computer models, anthropometrics; helicopter flight simulation: training, retraining, transfer of training, skill maintenance, visual system, motion system, training support features, design fidelity, workload validation; flight simulators for training: simulator sickness; aviator peer evaluation; aviator safety: accident prediction, flight proficiency; aviator training media: programs of instruction, simulators, interactive videotapes, interactive videodiscs, light attenuation filters, night vision goggles
Abstract: This report presents a summary of the work performed by Anacapa Sciences, Inc. (ASI) for ARIARDA at Fort Rucker, Alabama, under Contract No. MDA903-81-C-0504, "Human Factors Research in Aircrew Performance and Training." The report contains summary descriptions for each of 29 projects on which ASI personnel worked during the period 1 September 1982 to 31 December 1985. Each summary description contains (a) a background section that describes the rationale for the research and the research objectives, (b) a research rationale for the research and the research objectives, (c) a research approach section that describes the tasks and activities required to fulfill the project objectives, (d) a results section that describes the research findings, and (e) a project status section that describes the work completed and projections for future research, if any.

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Reference Type: Journal Article
Author: Crowell, James A.; Banks, Martin S.; Shenoy, Krishna V.; Andersen, Richard A.
Year: 1998
Title: Visual self-motion perception during head turns
Journal: Nature Neuroscience
Volume: 1
Pages: 732-737
Author's Title and Affiliation: Crowell, Shenoy, Andersen: Caltech Division of Biology, Mail Code 216-76, 1200 E. California Blvd., Pasadena, California 91125, USA
Banks: U.C. Berkeley School of Optometry, 360 Minor Hall, Berkeley, California, 94720-2020, USA
Abstract: Extra-retinal information is critical in the interpretation of visual input during self-motion. Turning our eyes and head to track objects displaces the retinal image but does not affect our ability to navigate because we use extra-retinal information to compensate for these displacements. We showed observers animated displays depicting their forward motion through a scene. They perceived the simulated self-motion accurately while smoothly shifting the gaze by turning the head, but not when the same gaze shift was simulated in the display; this indicates that the visual system also uses extra-retinal information during head turns. Additional experiments compared self-motion judgments during active and passive head turns, passive rotations of the body and rotations of the body with head fixed in space. We found that accurate perception during active head turns is mediated by contributions from three extra-retinal

cues: vestibular canal stimulation, neck proprioception and an efference copy of the motor command to turn the head.
Author Address: James Crowel: jim@vis.caltech.edu

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Reference Type: Conference Paper
Author: Cunningham, Kevin; Foster, John V.; Shah, Gautam H.; Stewart, Eric C.; Rivers, Robert A.; Wilborn, James E.; Gato, William
Year: 2004
Title: Simulation study of a commercial transport airplane during stall and post-stall flight
Conference Name: 2004 World Aviation Congress
Conference Location: Reno, NV
Publisher: SAE International
Date: November 2-4
Electronic Resource Number: 2004-01-3100
Author's Title and Affiliation: Kevin Cunningham, John V. Foster, Gautam H. Shah, Eric C. Stewart: NASA Langley Research Center
Robert A. Rivers: NASA Johnson Space Center
James E. Wilborn, William Gato: The Boeing Company
Keywords: upset recovery training (URT)
Abstract: As part of NASA's Aviation Safety and Security Program, a simulation study of a twin-jet transport aircraft crew training simulation was conducted to address fidelity for upset or loss-of-control flight conditions. Piloted simulation studies were conducted to compare the baseline crew training simulation model with an enhanced aerodynamic model that was developed for high-angle-of-attack conditions. These studies were conducted in flaps-up configuration and covered the approach-to-stall, stall and post-stall flight regimes. Qualitative pilot comments and preliminary comparison with flight test data indicate that the enhanced model is a significant improvement over the baseline. Some of the significant unrepresentative characteristics that are predicted by baseline crew training simulation for flight in the post-stall regime have been identified. This paper presents preliminary results of this simulation study and discusses key issues regarding predicted flight dynamics characteristics during loss-of-control flight conditions.

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Reference Type: Report
Author: Cyrus, Michael L.
Year: 1978
Title: Motion systems role in flight simulators for flying training
Institution: Air Force Human Resources Lab Brooks AFB TEX
Date: Aug
Number of Pages: 32
Accession Number: ADA059744
Keywords: flight training, fight simulators, military requirements, cost effectiveness, skills, pilots, motion, operational effectiveness, air force training, transfer of training
Abstract: This report reviews the literature as it relates to the use of platform motion systems in flight simulators for flying training. Motion is discussed in terms of its effect on compensatory, pursuit, and precognitive tasks, within both the simulator and transfer contexts. Although both skilled and unskilled behaviors are addressed, the former is emphasized. The report concludes that, for most tasks, platform motion is not required to produce rapid, efficient, economical training, and that other, less expensive means of imparting motion information are equally viable alternatives. The report recommends the following: (1) Whenever feasible and affordable, simulator systems should be equipped with the largest field-of-view visual system that is consistent with mission requirements, and (2) Simulators that do not include a platform motion system can be safely procured for most aircraft without compromising training effectiveness.
URL: http://oai.dtic.mil/oai/oai?verb=getRecord&metadataPrefix=html&identifier=ADA059744

Reference Type: Conference Proceedings
Author: Damveld, H.J.; Abbink, D.A.; Mulder, M.; Mulder, M.; van Paassen, M.M.; van der Helm, F.C.T.; Hosman, R.J.A.W.
Year of Conference: 2009
Title: Measuring the contribution of the neuromuscular system during a pitch control task
Conference Name: AIAA Modeling and Simulation Technologies Conference
Conference Location: Chicago, IL
Publisher: American Institute of Aeronautics and Astronautics (AIAA)
Pages: 1-19
Date: Aug. 10
Electronic Resource Number: AIAA-2009-5824
Author's Title and Affiliation: Damveld: Postdoctoral Research Fellow, Faculty of Aerospace Engineering, Control and Simulation Division, Delft University of Technology, Delft, The Netherlands
Abbink: Assistant Professor, Biomechanical Engineering, Delft University of Technology, Delft, The Netherlands
Mulder: Researcher, Faculty of Aerospace Engineering, Control and Simulation Division, Delft University of Technology, Delft, The Netherlands
Mulder: Professor, Faculty of Aerospace Engineering, Control and Simulation Division, Delft University of Technology, Delft, The Netherlands
van Paassen: Associate Professor, Faculty of Aerospace Engineering, Control and Simulation Division, Delft University of Technology, Delft, The Netherlands
van der Helm: Professor, Biomechanical Engineering, Delft University of Technology, Delft, The Netherlands
Hosman: Director, AMS Consult, Delftgauw, The Netherlands
Number of Pages: 19
Keywords: pilot models, neuromuscular system, feedback
Abstract: Current pilot models oversimplify the neuromuscular system as a second-order low-pass filter, merely focusing on its role in limiting the stick position bandwidth. However, the neuromuscular system also functions as a fast feedback control system due to reflexive activity and inherent muscle visco-elasticity, allowing pilots to respond intuitively to control column forces, much faster than visual or vestibular cues would allow. Models that neglect this property of the neuromuscular system erroneously attribute its activity to the visual or vestibular system when their parameters are estimated by system identification methods.
This paper's aim is to show a proof-of-concept for a novel method to supplement the currently used pilot models with measurements for the neuromuscular system. These measurements will form the basis for more detailed neuromuscular models, allowing a better description of the contribution of the visual, vestibular, and neuromuscular feedback to the pilot's control output. In this paper the novel method's modeling outcome (lumped arm inertia, viscosity and stiffness) will be compared to the conventional neuromuscular estimation (indirect estimation of natural frequency and relative damping).
A limited study was performed to provide data for parameter fits of a linearized pilot model for 1 DOF pitch control tasks. In the motion-based SIMONA Research Simulator (SRS) a pilot was instructed to perform a pursuit pitch-tracking task, in face of turbulence on the aircraft, and control force perturbations on the control column. In a novel perturbation method, these three forcing functions (perturbing the visual tracking signal, disturbing the aircraft's elevator deflection and the control-force cues) were designed to contain power at three different frequency sets, allowing simultaneous identification of three corresponding frequency response functions. Additionally, a separate experiment was done to demonstrate the adaptability of the neuromusculoskeletal system, showing that a pilot can become approximately ten times more stiff or compliant than during relaxed conditions.
The parameters in the visual, vestibular and neuromuscular system models are estimated by a combination of model-based system identification techniques in the frequency domain. The novel method provides estimated values for the pilot's lumped arm dynamics (inertia, viscosity and stiffness) while executing a pitch control task. For this task, the corresponding relative damping and natural frequency are in the same order of magnitude as those estimated in the conventional method.

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Reference Type: Journal Article
Author: Davies, D. P.
Year: 1975
Title: Approval of flight simulator flying qualities
Journal: The Aeronautical Journal
Volume: 79
Issue: 775
Pages: 281-297
Author's Title and Affiliation: D. P. Davies, Chief Test Pilot, Civil Aviation Authority (CAA)
Number of Pages: 17
Abstract: (taken from 1. INTRODUCTION) Flight Simulation has made good steady progress over the years, and is now being given significant credit for its ability to reproduce aircraft flying qualities in a device on the ground. However, the simulator flight world is tending to claim too much credit for its present level of achievement. This talk is an attempt to review the present state of the art against an accurate comparison with aircraft flying qualities, to highlight the deficiencies and to appeal to the users of simulators to consolidate their present gains before proceeding further. This paper deals only with civil fixed-wing transport aircraft above 20,000 kg maximum weight.
There are three parts:
(i) a brief statement of the approval procedures in the UK;
(ii) a review of the present level of simulator flying qualities;
(iii) some elementary advice to all involved in simulation.
In order to avoid my having to indulge in repeated supposition, let us assume that the readers are all applicants for the approval of a flight simulator so that I may enjoy the use of personal pronouns.
As my last introductory comment, I must admit that I know really very little about flight simulators: the vocabulary alone for example baffles me. However, this admission is not significant. I do know a good deal about the flying qualities of contemporary aeroplanes and as the accurate simulation of aircraft flying qualities is the target of the flight simulator world then who better to discuss the subject than a specialist in the end product? I sometimes feel that my ignorance is not a bad thing anyway: if I knew a lot more of your difficulties, for example, it might cause my natural sympathy and kindness to warp my judgment. A measure of kindness is necessary otherwise the number of simulators presently approved would be significantly lower. For the proof of this last point read on.

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Reference Type: Journal Article
Author: Day, R. H.; Wade, N. J.
Year: 1969
Title: Mechanisms involved in visual orientation constancy
Journal: Psychological Bulletin
Volume: 71
Issue: 1
Pages: 33-42
Author's Title and Affiliation: Monash University, Australia
Keywords: anatomy, judgment, orienting reflex, somesthetic perception, visual perception
Abstract: Visual orientation judgments made during body tilt (E- and A- effects), during centrifugation (oculogravic effect), and following prolonged tilt (aftereffect) are interpreted in terms of visual orientation constancy. Data from two classes of experiments, those using labyrinthine-defective subjects and those involving different combinations of posture, indicate that three systems are involved in orientation constancy. These are the vestibular otolith system and the proprioceptive systems of the neck and the trunk. Although the three systems are involved in the E-, A-, and oculogravic effects, adaptation of only the neck and trunk systems generate the aftereffect.

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Reference Type: Conference Proceedings
Author: de Bruin, J.; Grant, P.R.; Mulder, M.; van Paassen, M.M.; Zaal, P.M.T.

Year of Conference: 2007
Title: Pilot's use of heave cues in a pitch control task
Conference Name: AIAA Modeling and Simulation Technologies Conference and Exhibit
Conference Location: Hilton Head, SC
Publisher: American Institute of Aeronautics and Astronautics (AIAA)
Date: August 20-23
Electronic Resource Number: AIAA 2007-6895
Author's Title and Affiliation: de Bruin: MSc. student, Control and Simulation Division, Faculty of Aerospace Engineering, Delft University of Technology, P.O. Box 5058, 2600 GB Delft, The Netherlands
Grant: Associate Professor, University of Toronto Institute for Aerospace Studies
Mulder: Associate Professor, Control and Simulation Division, Faculty of Aerospace Engineering, Delft University of Technology, P.O. Box 5058, 2600 GB Delft, The Netherlands
van Paassen: Associate Professor, Control and Simulation Division, Faculty of Aerospace Engineering, Delft University of Technology, P.O. Box 5058, 2600 GB Delft, The Netherlands
Zaal: PhD student, Control and Simulation Division, Faculty of Aerospace Engineering, Delft University of Technology, P.O. Box 5058, 2600 GB Delft, The Netherlands
Abstract: This paper reports on a pitch control experiment performed in the UTIAS Flight Research Simulator (FRS), investigating the effects of pitch and heave motion on pilot performance and control effort in a pitch attitude control task. Few pitch attitude control experiments have been reported that investigate the influence of heave and pitch motion on pitch control. Moreover, experimental results as reported in literature, are in disagreement about the influence of heave motion on pitch control. In this paper, the preliminary results of the experiment are presented. Two types of heave motion cues are studied. The first is a linear function of pitch rate, representing heave acceleration as a result of aircraft lift, the second is a linear function of pitch acceleration, representing heave acceleration as a result of the rotating aircraft. A combined target tracking and disturbance rejection task was performed with a compensatory display. The dependent measure analysis shows a significant increase in performance when pitch motion is added. An improvement in performance is visible for heave motion, though not significant. No significant differences are found for the two types of heave acceleration. Further in-depth analysis is currently conducted, including pilot describing function analysis by identification, and pilot model analysis.

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Reference Type: Book Section
Author: De Marco, Agostino
Year: 2003
Title: A brief history of aircraft flight simulation
Book Title: Appunti di Tecniche di Simulazione di Volo (Notes on Flight Simulation Techniques)
City: Naples, Italy
Publisher: unpublished work
Pages: 2-1 - 2-37
Chapter: 2
Author's Title and Affiliation: Agostino De Marco, PhD, Università degli Studi di Napoli "Federico II" (University of Naples (Italy) "Federico II"), Dipartimento di Progettazione Aeronautica (DPA) (Department of Aerospace Engineering), Aircraft Design & Aeroflightdynamics Group (ADAG)
Keywords: history, flight simulation, simulation techniques
Abstract: A complete account of the development of the technology of flight simulation would not be narrow in scope despite its recent birth. Flight simulation has made immediate use of advantages in technology throughout a 75-year history and indeed, its demands have often stimulated new developments in the supporting technologies.
The review presented here will focus on the evolution of technologies for flight simulation with the aid of illustrations of devices which best represent the major advancing steps.
The majority of flight simulation devices were built for training purposes, although of course flight simulation includes machines built for engineering and psychological research. Most of these latter are simulators built for training non-piloting tasks of aircrews, such as navigation, radio operation and gunnery, and are omitted here.

Notes: This appears to be an unpublished chapter of course notes written in book form (used for teaching).
See also http://www.dpa.unina.it/demarco/, click on Teaching Area/Tecniche di Simulazione di Volo for other chapters including:
1: An introduction to Flight Simulation
2: A Brief History of Aircraft Flight Simulation
3: Mathematical models
4: Flight Instruments
5: Navigation Systems (draft)
URL: http://www.dpa.unina.it/demarco/docs/app_tecniche_simulazione_volo_cap_2.pdf
Author Address: Phone: +39 081 768 3323
Fax: +39 081 768 3622
E-mail: agodemar@unina.it

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Reference Type: Conference Proceedings
Author: de Vroome, A. M.; Valente Pais, A. R.; Pool, D. M.; van Paassen, M. M.; Mulder, M.
Year of Conference: 2009
Title: Identification of motion perception thresholds in active control tasks
Conference Name: AIAA Modeling and Simulation Technologies Conference
Conference Location: Chicago, IL
Publisher: American Institute of Aeronautics and Astronautics (AIAA)
Pages: 1-20
Date: Aug. 10-13
Electronic Resource Number: AIAA-2009-6243
Author's Title and Affiliation: de Vroome: MSc student, Control and Simulation Division, Faculty of Aerospace Engineering, Delft University of Technology, Delft, The Netherlands
Valente Pais: PhD student, Control and Simulation Division, Faculty of Aerospace Engineering, Delft University of Technology, Delft, The Netherlands
Pool: PhD student, Control and Simulation Division, Faculty of Aerospace Engineering, Delft University of Technology, Delft, The Netherlands
van Paassen: Associate Professor, Control and Simulation Division, Faculty of Aerospace Engineering, Delft University of Technology, Delft, The Netherlands
Mulder: Professor, Control and Simulation Division, Faculty of Aerospace Engineering, Delft University of Technology, Delft, The Netherlands
Number of Pages: 20
Keywords: motion perception thresholds, vestibular motion, SIMONA Research Simulator
Abstract: In the design of a high fidelity simulator environment, knowledge about motion perception thresholds is essential. Thresholds are generally measured in a passive experimental setup, in which subjects do not actively influence their motion profile. In this paper, a method for analytical identification of motion perception thresholds in active control tasks is proposed. The effect of vestibular motion on thresholds was analyzed and a comparison to conventional passive threshold measurements was made. The threshold identification method was based on a multi-channel pilot model extended with a nonlinear absolute threshold element. Maximum likelihood parameter estimation, combining a Genetic Algorithm and an unconstrained Gauss-Newton algorithm optimization, was applied. A theoretical study indicated that there is an upper limit to the vestibular motion amplitude to allow accurate threshold identification. Two experiments were performed in the SIMONA Research Simulator to test the application of the method. A passive experiment to measure the sensory pitch threshold and an active control task to identify the active pitch threshold [was conducted]. In the active experiment, the vestibular motion amplitude was varied and two types of control tasks were used. For the disturbance-rejection task, the pitch threshold was only identifiable for high motion amplitude levels. The target-tracking task allowed identification of the threshold for medium and high amplitude levels. Neither of the tasks allowed threshold identification with low levels of motion amplitude. The pitch thresholds obtained from the active and passive experiment were in the same order of magnitude.

Reference Type: Conference Paper
Author: Dearing, M.; Schroeder, J.; Sweet, B.; Kaiser, M.
Year: 2001
Title: Effects of visual texture, grids, and platform motion on unpowered helicopter landings
Conference Name: AIAA Modeling and Simulation Technologies Conference and Exhibit
Conference Location: Montreal, Quebec, Canada
Date: August 6-9
Electronic Resource Number: AIAA 2001-4251
Author's Title and Affiliation: NASA Ames Research Center, Moffett Field, CA
Number of Pages: 11
Abstract: A simulation experiment examined how a range of visual and platform motion characteristics affected a pilot's ability to perform precise landings after a steep unpowered descent in a helicopter. The visual characteristics were texture density and different sized rectangular grids. The platform motion levels ranged from fixed-base to extremely large motion. Seven experienced test pilots flew all 36 visual and motion combinations, and their objective performance and subjective opinions were collected. Texture affected all of the dependent measures; however, the finest texture did not perform the best, which debunks a common misperception that more texture is better. In contrast, grids only affected pilot subjective opinion of speed and attitude cueing. As more platform motion was added, touchdown sink rate improved, along with pilot opinion of the motion fidelity.

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Reference Type: Conference Paper
Author: DeBerg, Oak H.; McFarland, Barry P.; Showalter, Thomas W.
Year: 1976
Title: The effect of simulator fidelity on engine failure training in the KC-135 aircraft
Conference Name: AIAA Visual and Motion Simulation Conference
Conference Location: Dayton, OH
Publisher: American Institute of Aeronautics and Astronautics (AIAA)
Date: April 26-28
Electronic Resource Number: AIAA-1976-1710
Author's Title and Affiliation: Aeronautical Systems Division, United States Air Force, Wright-Patterson AFB, OH 45433
Number of Pages: 5
Abstract: Because of the dangers associated with engine failures during takeoff of large multi-engine aircraft, flight simulators are usually used to train pilots to recover from this failure. An assessment of the effectiveness of this training was made using an engineering flight simulator with KC-135A aircraft commanders as test subjects. The available visual system and motion system cueing capabilities of the engineering simulator were restricted to produce four combinations representative of current training hardware: (a) visual system cues only, (b) motion system cues only, (c) visual system and motion system cues, and (d) no visual system and motion system cues. One subject group was trained to recover from engine failure in each of these cueing situations. All restrictions to the cueing of the engineering simulator were then removed, and training effectiveness of the four candidate systems was assessed by measuring pilot performance in the unrestricted engineering simulator. Results were analyzed by a factorial analysis of variance. Results indicate: (a) the superiority of training effectiveness with simulator visual systems, (b) the enhancement of training effectiveness by including a motion system in the training simulator, and (c) the synergistic improvement in training using both motion and visual systems together. This experiment is the first of a series that will investigate simulation cueing effectiveness.

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Reference Type: Report
Author: Dell, W.
Year: 2000
Title: The use of 3-D to improve auditory cues in aircraft
Pages: 1-101

Author's Title and Affiliation: Department of Computing Science, University of Glasgow, Lilybank Gardens, Glasgow, G12 8QQ
Number of Pages: 102
Abstract: Auditory alarms are being used in many safety critical environments such as hospitals, nuclear power stations and aircraft. At present, these auditory alarms rarely make use of the fact that sound can be processed to come from more than one direction. Looking at aviation in particular, it is common for pilots to wear headphones that support stereo sound, which means that taking advantage of this aspect of audio is certainly feasible. Additionally, a 3D virtual acoustic display was proposed by Wenzel [1] when there was insufficient technology to test her assertions. However, with the release of DirectX 5.0, it is now practical to design and prototype auditory alarms that make use of 3D audio. This project investigates the impact of using spatialised alarms versus stereo and mono alarms. The effectiveness of the three types of alarm are analyzed in terms of reaction time, error rate, learnability, performance of primary task and workload measures. The results from this experiment indicate that the technology for supporting 3D audio is not sufficient to yield an advantage over its alternatives.

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Reference Type: Report
Author: Demuth, Jan; Helmreich, Bob; Lofaro, Ron; Smith, Kevin
Year: 1991
Title: Crew resource management (CRM)
Date: September 20
Type: Advisory Circular Draft
Report Number: 120-51 Draft 2.4
Author's Title and Affiliation: Demuth, Helmreich, Lofaro, Smith: CRM/Los Integration Subcommittee, ATA/AQP Working Group
Number of Pages: 22

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Reference Type: Report
Author: den Hollander, J. G.; Baarspul, M.
Year: 1977
Title: Measurement of motion quality of a moving base flight simulator
Author's Title and Affiliation: den Hollander, Baarspul: Delft University of Technology, Faculty of Aerospace Engineering
Notes: Memorandum M-264. Referenced in Ruud Hosman's book, *Pilot's perception and control of aircraft motions* (1996).

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Reference Type: Report
Author: Denne, Phillip R.M.
Year: 1994
Title: Motion effects on driver training
City: Bournemouth, England
Institution: Denne Developments Ltd.
Author's Title and Affiliation: Managing Director, Denne Developments Ltd., Bournemouth. England
Number of Pages: 4
Abstract: Driver training in a non-motion simulator does not teach all the skills which are critical in the real world, because nobody drives in direct response to visual feedback information. The fast-response loop on which all trained reactions are based is a haptic one which includes tactile feedback from the controls and from the sensations of vehicle movement caused by control actions or by the irregularities of the environment. It follows that no driver training simulator is complete without well-designed motion and control-loading systems. Recent developments allow these to be provided at an acceptable cost.
URL: http://www.advancedmotion.net/pdf/sim5.pdf

Reference Type: Conference Paper
Author: Dennerlein, J. T.; Martin, D. B.; Hasser, C.
Year: 2000
Title: Force-feedback improves performance for steering and combined steering-targeting tasks
Conference Name: Conference on Human Factors in Computing Systems
Date: April 1-6
Author's Title and Affiliation: Jack Tigh Dennerlein: Harvard University, 665 Huntington Ave, Boston, MA
David B. Martin: Harvard University & Dartmouth College, Hanover, NH
Christopher Hasser: Stanford University & Immersion Corporation, 2158 Paragon Drive, San Jose, CA
Abstract: The introduction of a force-feedback mouse, which provides high fidelity tactile cues via force output, may represent a long-awaited technological breakthrough in pointing device designs. However, there have been few studies examining the benefits of force-feedback for the desktop computer human interface. Ten adults performed eighty steering tasks, where the participants moved the cursor through a small tunnel with varying indices of difficulty using a conventional and force-feedback mouse. For the force-feedback condition, the mouse displayed force that pulled the cursor to the center of the tunnel. The tasks required both horizontal and vertical screen movements of the cursor. Movement times were on average 52 percent faster during the force-feedback condition when compared to the conventional mouse. Furthermore, for the conventional mouse vertical movements required more time to complete than horizontal screen movements. Another ten adults completed a combined steering and targeting task, where the participants navigated through a tunnel and then clicked a small box at the end of the tunnel. Again, force-feedback improved times to complete the task. Although movement times were slower than [sic] the pure steering task, the steering index of difficulty dominated the steering-targeting relationship. These results further support that human computer interfaces benefit from the additional sensory input of tactile cues to the human user.

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Reference Type: Newspaper Article
Reporter: Der Bund (sda)
Year: 1998
Title: Das Vertrauen verloren
Newspaper: Der Bund
Issue Date: April 15
Keywords: F/A-18, disorientation, upset recovery training (URT)
Notes: Swiss Army accident by older pilot.

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Reference Type: Journal Article
Author: Di Renzo, John C. Jr.
Year: 2006
Title: Developing strategies for the modern international airport
Journal: International Journal of Applied Aviation Studies
Volume: 6
Issue: 2
Pages: 335-338
Type of Article: Book Review
Number of Pages: 4
Abstract: A review of the book *Developing Strategies for the Modern International Airport East Asia and Beyond* by Allan Williams

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Reference Type: Book Section
Author: Dichgans, J.; Brandt, Th.
Year: 1978
Title: Visual-vestibular interactions: Effects on self-motion perception and postural control
Editor: Held, R.; Leibowitz, H. W.; Teuber, H.-L.
Book Title: Handbook of Sensory Physiology
City: Berlin
Publisher: Springer-Verlag
Volume: 8, Perception
Pages: 755-804
Chapter: 25

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Reference Type: Report
Author: Dieudonne, James E.; Parrish, Russell V.; Bardusch, Richard E.
Year: 1972
Title: An actuator extension transformation for a motion simulator and an inverse transformation applying Newton-Raphson's method
City: Washington, D.C.
Institution: National Aeronautics and Space Administration
Date: November
Type: Technical Note
Report Number: NASA TN D-7067
Number of Pages: 20
Keywords: Motion simulator
Newton-Raphson method
Real-time simulation
Abstract: A set of equations which transform position and angular orientation of the centroid of the payload platform of the six-degree-of-freedom motion simulator at the Langley Research Center into extensions of the simulator's actuators has been derived and is based on a geometrical representation of the system. An iterative scheme, Newton-Raphson's method, has been successfully used in a real-time environment in the calculation of the position and angular orientation of the centroid of the payload platform when the magnitude of the actuator extensions is known. Sufficient accuracy is obtained by using only one Newton-Raphson iteration per integration step of the real-time environment.

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Reference Type: Report
Author: Dillard, A. E.
Year: 2002
Title: Validation of advanced flight simulators for human-factors operational evaluation and training programs
Pages: 1-87
Date: September 12
Type: Draft
Number of Pages: 88
Abstract: (Scope) This document is meant to deal with the process of validating advanced approved flight simulators as described in AC 120-40 for human-factors, procedural development, and operational evaluation programs. There are other levels of simulation available, and all have an appropriate application in the process of modeling, evaluating, and analyzing a procedure or an operational application. The term "Approved" refers to the FAA's process of formally certifying, or approving, simulators for use in approved training programs. Approved simulators are all based on the use of actual aircraft databases derived from flight test data and qualified pilot operators to ensure a high fidelity operating environment.

Reference Type: Journal Article
Author: Dixon, Peter; Gabrys, Gareth
Year: 1991
Title: Learning to operate complex devices: Effects of conceptual and operational similarity
Journal: Human Factors
Volume: 33
Issue: 1
Pages: 103-120
Author's Title and Affiliation: Dixon: University of Alberta at Edmonton
Gabrys: University of Pittsburgh, PA
Number of Pages: 17
Abstract: In two experiments we investigated the effect of prior knowledge of a given device on learning to operate a similar device. Two kinds of similarity were investigated: conceptual similarity, in which the underlying concepts of how the devices worked were the same, and operational similarity, in which the organization and structure of the operating system were the same. Experiment 1 used devices that were always physically the same, regardless of how they were described and the procedure used to operate them. Experiment 2 used devices that were always physically different but required the same logical sequence of steps. In both experiments there were substantial effects of operational similarity, but no reliable effect of conceptual similarity. It was concluded that prior experience with similar devices often helps because similar devices have similar operating procedures, not because similar devices work similarly.

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Reference Type: Journal Article
Author: DiZio, Paul; Lackner, James R.
Year: 2001
Title: Coriolis-force-induced trajectory and endpoint deviations in the reaching movements of labyrinthine-defective subjects
Journal: Journal of Neurophysiology
Volume: 85
Issue: 2
Pages: 784-789
ISSN: 0022-3077
Number of Pages: 6
Accession Number: 2002-12236-010
Keywords: reaching movements, labyrinthine-defective Ss, motor control, motor adaption during rotation
Abstract: When reaching movements are made during passive constant velocity body rotation, inertial Coriolis accelerations are generated that displace both movement paths and endpoints in their direction. These findings directly contradict equilibrium point theories of movement control. However, it has been argued that these movement errors relate to subjects sensing their body rotation through continuing vestibular activity and making corrective movements. In the present study, we evaluated the reaching movements of five labyrinthine-defective subjects (lacking both semicircular canal and otolith function) who cannot sense passive body rotation in the dark and five age-matched, normal control subjects. Each pointed 40 times in complete darkness to the location of a just extinguished visual target before, during, and after constant velocity rotation at 10 rpm in the center of a fully enclosed slow rotation room. All subjects, including the normal controls, always felt completely stationary when making their movements.During rotation, both groups initially showed large deviations of their movement paths and endpoints in the direction of the transient Coriolis forces generated by their movements. With additional per-rotation movements, both groups showed complete adaptation of movement curvature (restoration of straight-line reaches) during rotation. The labyrinthine- defective subjects, however, failed to regain fully accurate movement endpoints after 40 reaches, unlike the control subjects who did so within 11 reaches. Postrotation, both groups' movements initially had mirror image curvatures to their initial per-rotation reaches; the endpoint aftereffects were significantly different from prerotation baseline for the control subjects but not for the labyrinthine-defective subjects reflecting the smaller amount of endpoint adaptation they achieved during rotation. The labyrinthine-defective subjects' movements had

significantly lowerpeak velocity, higher peak elevation, lower terminal velocity, and a more vertical touchdown than those of the control subjects. Thus the way their reaches terminated denied them the somatosensory contact cues necessary for full endpoint adaptation. These findings fully contradict equilibrium point theories of movement control. They emphasize the importance of contact cues in adaptive movement control and indicate that movement errors generated by Coriolis perturbations of limb movements reveal characteristics of motor planning and adaptation in both healthy and clinical populations.

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Reference Type: Conference Paper
Author: Doll, T. J.
Year: 1986
Title: Synthesis of auditory localization cues for cockpit applications
Conference Name: Human Factors Society 30th Annual Meeting
Conference Location: Dayton, OH
Date: September 29-October 3
Author's Title and Affiliation: Georgia Tech Research Institute, Atlanta, GA
Number of Pages: 5
Abstract: The long-term objective of this work is to develop techniques for conveying accurate spatial information via audio signals delivered to the listener through headphones. Specific objectives of the first phase included the design, fabrication, and evaluation of an apparatus for demonstrating simulated auditory localization (SAL). The design of the SAL facility is described. An experimental test of the psychological fidelity of the SAL facility is summarized. The results show that the facility produces a high-fidelity simulation of normal, unaided auditory localization.

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Reference Type: Magazine Article
Author: Donoghue, J. A.
Year: 2009
Title: Beyond compliance
Magazine: Aero Safety World
Pages: 17-19
Date: April
Number of Pages: 3
Abstract: Seminar speakers stress the need to exceed basic requirements

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Reference Type: Report
Author: Douvillier, Joseph G., Jr.; Turner, Howard L.; McLean, John D.; Heinle, Donovan R.
Year: 1960
Title: Effects of flight simulator motion on pilots' performance of tracking tasks
City: Washington, DC
Institution: National Aeronautics and Space Administration (NASA)
Date: February
Report Number: NASA TN D-143
Author's Title and Affiliation: NASA Ames Research Center, Moffett Field, CA
Number of Pages: 34
Abstract: The effect of motion of a flight simulator on pilots' performance of a tracking task has been investigated by comparing the air-to-air tracking performance of two pilots in flight, on a motionless flight simulator, and on a flight simulator free to roll and to pitch. Two different attack displays were used.
It was found in tracking a maneuvering target that: the results from the moving flight simulator resembled the results from flight much more than did those from the motionless simulator; and that in flight the conventional circle-dot display was superior to a drone display. For simpler tracking tasks it was not possible to detect these differences.

Reference Type: Magazine Article
Author: Dow, John P. Sr.
Year: 2005
Title: Understanding the stall-recovery procedure for turboprop airplanes in icing conditions
Magazine: Flight Safety Digest
Volume: 24
Issue Number: 4
Pages: 1-17
Date: April
Keywords: upset recovery training (URT)
Abstract: Current pilot training typically emphasizes powering through a stall recovery with no loss of altitude. Nevertheless, when flying a turboprop airplane that has accumulated ice, lowering the nose to reduce angle-of-attack is imperative. Here's why.
URL: http://www.flightsafety.org/fsd/fsd_apr05.pdf

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Reference Type: Conference Proceedings
Author: Dransfield, Mark
Year of Conference: 2009
Title: 27 Into 7 Equals 9625--The New Regulatory Matrix
Conference Name: World Aviation Training Symposium
Conference Location: Orlando, FL
Notes: This was a PowerPoint presentation given at the WATS April 2009 Conference in Orlando on the revision and expansion of International Civil Aviation Organization ICAO Doc. 9625, Manual of Criteria for the Qualification of Flight Simulation Training Devices (FSTD). Volume I on fixed-wing airplanes was published on July 1st, 2009, and is available in English from the ICAO Online Store at <http://store1.icao.int/documentItemView.ch2?ID=7673>. Volume I of the manual covers the qualification criteria for aeroplane FSTD. Work continues on Volume II, which will address the criteria for rotary wing FSTD. The rotary group of the IWG expects to present its draft to ICAO and the RAeS in early 2010 to be published late that year. Both volumes contain three parts.

Part I, Training Task Derived Flight Simulation Requirements is based on an analysis of airline-pilot training needs and lists the features (e.g., cues) and fidelity levels required to support each task.

Part II, Flight Simulation Training Device Criteria, lists criteria for standard examples of FSTD derived from Part I, supporting defined training types (e.g., MPL1 - Multi-crew Pilot Licence - Phase 1, Core flying skills). Volume I defines seven example FSTD. Volume II is expected to offer three or four example helicopter FSTD.

Part III, Flight Simulation Feature and Fidelity Level Criteria serves to define the qualification and validation testing requirements for feature-fidelity levels determined in Part I. It will allow operators and manufacturers to design purpose-built devices that do not correspond to any of the standard examples defined in Part II. It will also permit currently qualified FSTD to be upgraded to meet new regulations by comparing their features with those defined in Part I.

In Volume I, the challenge of defining objective criteria for the evaluation of motion systems leaves this area subject to further study. Similarly, the lack of technical solutions to simulate a full air-traffic-control environment requires further research. Nevertheless, both items are addressed in the document. The challenge for the helicopter group working on Volume II has been evaluating the constraints imposed by the use of collimated visual systems versus the problems arising from direct view visual systems (e.g., dome projected displays). The solution may depend on the type of helicopter and its cockpit layout. The roles of motion and vibration and their integration with visual systems have also received particular attention. (From draft submission of “Year in Review” article for Aerospace America, written by jbc.)*****

Reference Type: Report
Author: Draper, Mark
Year: 1996
Title: Can your eyes make you sick? Investigating the relationship between the vestibulo-ocular reflex and virtual reality
Date: April 29
Type: Technical report
Keywords: simulator sickness, vestibulo-ocular reflex, visual, vestibular, tracking
Abstract: This paper discusses the nature of the vestibulo-ocular reflex and its relationship to the tracking response of the eye. Included is a simplistic descriptive model of these mechanisms. Speculations are then made on the potential contributions of the visual and vestibular systems in producing "simulator sickness" and in particular the kinds of artifacts in virtual interfaces that may contribute to this condition.
Notes: On 2/23/07, the web page was no longer available.
URL: http://www.hitl.washington.edu/publications/r-96-3/

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Reference Type: Conference Paper
Author: Driskell, Carl R.
Year: 1978
Title: Wide angle visual system developments
Conference Name: Flight Mechanics Panel Specialists' Meeting on Piloted Aircraft Environment Simulation Techniques
Conference Location: Brussels, Belgium
Publisher: Advisory Group for Aerospace Research and Development (AGARD)
Date: April 24-27
Author's Title and Affiliation: Project Director, US Army Office of Project Manager for Training Devices, Naval Training Equipment Center, Orlando, FL 32813
Number of Pages: 12
Keywords: wide angle visual system, scanned laser visual system, focus, resolution, attitude control
Abstract: The US Army Project Manager for Training Devices has two competing development programs designed to provide high resolution tactical scenes over a wide field of view for pilot training. In the first system, a laser beam scans the portion of a terrain model board to be presented to the pilot. A matrix of light sensors collects the light reflected from the model board. A composite video signal from the light sensors modulates a laser beam in the display scanner which scans the scene onto a spherical viewing screen. In the second system, an optical probe picks up a 360-degree annular image of a terrain model board. The annular image is scanned onto a radial array of charged coupled devices which converts the annular display into video signals. The video signals modulate the laser beams into an annular laser projector which scans the scene through an annular projection lens onto a spherical viewing screen. Both visual systems provide continuous seamless visual scenes without color matching, edge matching or brightness matching problems that arise in multiple window display systems.

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Reference Type: Magazine Article
Author: Duke, Thomas A.
Year: 2003
Title: Safer Skies position report: Accident reduction on glidepath - Safety enhancements progress
Magazine: Air Line Pilot
Volume: 72
Issue Number: 8
Pages: 20-24
Date: September
Author's Title and Affiliation: Captain (Ret.), Air Line Pilots Association (ALPA)

Keywords: upset recovery training (URT), Air Line Pilots Association (ALPA), Safer Skies
Abstract: In 1997, the White House, followed up by the National Civil Aviation Review Commission, challenged the FAA, U.S. airlines, and the aviation industry to reduce in 10 years the fatal accident rate by 80 percent over the 1994-96 rates per 100,000 departures. The challenge also extended to reducing the rate of overall accidents (fatal and nonfatal) and reducing the rate of fatalities in each major type of accident. Further, the airline industry, government, associations, and unions were to collaborate and provide the research to support that challenge. The FAA responded to the challenge with the project Safer Skies.
At the North American Aviation Safety Conference, held February 4-6 in Atlanta and sponsored by SAE Aerospace and the Flight Safety Foundation, both FAA Administrator Marion Blakey and NTSB member Carol Carmody congratulated the U.S. airline industry (including scheduled Part 135 carriers) for flying fatality-free in the calendar year 2002. Blakey stated, "The goal of reaching an 80 percent reduction [in the U.S. airline accident rate] by 2007 is well on track, with a 49 percent reduction at the halfway point. "Last month's [January 2003] accident in Charlotte shows that we have a long way to go," Blakey said. "We must change our reactive nature and adopt a proactive approach involving data gathering, analysis, and action before accidents happen."
Here is how the Safer Skies challenges look for the Part 121 air carriers now in 2003, with less than 5 years to go. The Part 121 air carriers fly about 95 percent of all airline flying being tracked for the 80 percent reduction numbers. For simplicity and clarity, the data deal with the accidents behind the official FAA rates per 100,000 departures.
URL: http://www.alpa.org/portals/alpa/magazine/2003/Sept2003_SaferSkies.htm

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Reference Type: Instructor Manual
Author: Dunlap, Joseph H.; Mangold, Susan J.
Year: 1998
Title: Leadership/followership: Recurrent training instructor manual
Date: February
Author's Title and Affiliation: Dunlap: Western Michigan University; Mangold: Battelle Memorial Institute

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Reference Type: Conference Proceedings
Author: Duppen, M.; Zaal, P.M.T.; Mulder, M.; Van Paassen, M.M.
Year of Conference: 2007
Title: Effects of motion on pilot behavior in target, disturbance and combined tracking tasks
Conference Name: AIAA Modeling and Simulation Technologies Conference and Exhibit
Conference Location: Hilton Head, SC
Publisher: American Institute of Aeronautics and Astronautics (AIAA)
Date: August 20-23
Electronic Resource Number: AIAA 2007-6894
Author's Title and Affiliation: Duppen: MSc. Student; Zaal: Ph.D. Candidate; Mulder: Associate Professor; Van Paassen: Associate Professor; Control and Simulation Division, Faculty of Aerospace Engineering, Delft University of Technology, P.O. Box 5058, 2600 GB Delft, The Netherlands
Abstract: In vehicle control, pilots merge the input from multiple sensory channels to produce the control input to the vehicle. In order to separate different channels from a multi-channel pilot model with the current identification techniques, multiple forcing functions need to be introduced in a simulator experiment. Then, it is assumed that “classical” target and disturbance tasks can be replicated by properly downsizing the power of the disturbance and target forcing function signals, respectively. It remains unclear, however, whether pilots adapt their control strategy in these combined tasks, in particular in the presence of motion. In order to analyze pilot behavioral adaptation, a multi-channel Optimal Control Model is developed and a simulator experiment is conducted. A range of combinations of forcing functions is tested in a simulator experiment. However, no apparent change of pilot behavior was found.

Reference Type: Conference Paper
Author: Dusterberry, John C.
Year: 1978
Title: Visual simulation requirements and hardware
Conference Name: Flight Mechanics Panel Specialists' Meeting on Piloted Aircraft Environment Simulation Techniques
Conference Location: Brussels, Belgium
Publisher: Advisory Group for Aerospace Research and Development (AGARD)
Date: April 24-27
Author's Title and Affiliation: Research Assistant to the Director, NASA Ames Research Center, Moffett Field, CA 94035
Number of Pages: 7
Keywords: visual simulation requirements, hardware
Abstract: Requirements for any out-of-the-cockpit visual system can easily lead to a set of system specifications which are clearly beyond the visual scene that can be produced by current technology. Therefore, the requirements of any proposed system must be assessed in light of the expected simulated aircraft and missions, experiments on pilot response, and available image generation and display hardware. A review is made of some of the recent experiments, and the results are related to aircraft and missions with particular emphasis on research and development simulators. Recent visual simulation hardware is considered in light of extending the range of applications of piloted aircraft simulators, and a method of design approach is proposed.

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Reference Type: Conference Paper
Author: Dusterberry, John C.
Year: 1985
Title: Manned flight simulation: Challenge and response
Conference Name: Flight Mechanics Panel Symposium on Flight Simulation
Conference Location: Cambridge, UK
Publisher: Advisory Group for Aerospace Research and Development (AGARD)
Date: September 30-October 3
Author's Title and Affiliation: Retired, NASA Ames Research Center, Moffett Field, CA 94035
Number of Pages: 7
Keywords: flight simulation, control simulation, pilot training
Abstract: Early AGARD papers on manned flight simulation describe the status of an emerging test technique and then offer suggestions of the problems that should be solved to advance the technique and predictions of the results obtained by its use. Later AGARD literature is examined to determine how these challenges have been met, both in ground-based and in-flight simulation and how AGARD has played an important role in advancing the technique so that it is now an integral part of the aerospace vehicle design process.
Notes: Published in September 1986

Reference Type: Report
Author: Edens, Eleana
Year: 1998
Title: Air carrier training research review
Institution: Federal Aviation Administration (FAA)
Date: May
Number of Pages: 33
Notes: Contains the Volpe Center project entitled, "Pilot Training and Evaluation: Airplane Simulation Human Factors."

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Reference Type: Report
Author: Edens, Eleana
Year: 2000
Title: Air carrier training research review
Institution: Federal Aviation Administration (FAA)
Date: June
Number of Pages: 53
Keywords: crew training and assessment, instructor training, Line-Oriented Flight Training (LOFT), Line-Oriented Evaluation (LOE)
Abstract: Although basic technical and Crew Resource Management (CRM) concepts are widely accepted, much remains to be learned regarding the appropriate methods for effective training and valid and reliable assessment of training programs. The general research philosophy guiding efforts to improve training and assessment is that research must consider distinct segments of aviation training systems. Individuals comprising the crew, instructors who train and evaluate crews in the classroom, the simulator and on the line, as well as the management culture responsible for the safety climate of the carriers should all be considered. Additionally, this research must regard the variables important to Line-Oriented Flight Training (LOFT) and Line-Oriented Evaluation (LOE) development, implementation and evaluation. Thus, this research centers on (1) crew training and assessment, (2) instructor training, (3) LOFT/LOE development strategies and (4) organizational and systematic influences on pilot performance, including automation usage.

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Reference Type: Journal Article
Author: Eklund, J. Mikael; Korenberg, Michael J.
Year: 2000
Title: Simulation of aircraft pilot flight controls using nonlinear system identification
Journal: Simulation
Volume: 75
Issue: 2
Pages: 72-81
Date: August
Author's Title and Affiliation: Department of Electrical and Computer Engineering at Queens University
Number of Pages: 10
Keywords: aerospace system simulation, flight control systems, full flight simulators, nonlinear system identification, parallel cascade identification
Abstract: This paper is concerned with modeling of the front end of an aircraft pilot flight control system's behavior using a nonlinear system identification technique known as parallel cascade identification. Using this technique, we are able to model a critical part of a pilot flight control system with sufficient accuracy to meet the objective test requirements of the U.S. Federal Aviation Administration for certifying full flight simulators. Traditional approaches to modeling such aircraft systems involve extensive analytical studies of the design of the system, lengthy and detailed empirical testing and recording of data from the physical system, and then considerable analysis to fit parametric models to the data. The approach presented in this paper virtually eliminates the need for analysis of the system in question, significantly reduces the

number of signals that need to be recorded from the real aircraft flight control system, and provides an extremely fast method of identifying the mathematical model based on these data. Overall, the time and costs associated with building an effective model are greatly reduced.

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Reference Type: Conference Proceedings
Author: Ellerbroek, J.; Stroosma, O.; Mulder, M.; van Paassen, M.M.
Year of Conference: 2007
Title: Identification of the roles of yaw and sway motion in helicopter yaw control tasks
Conference Name: AIAA Modeling and Simulation Technologies Conference and Exhibit
Conference Location: Hilton Head, SC
Publisher: American Institute of Aeronautics and Astronautics (AIAA)
Date: August 20-23
Electronic Resource Number: AIAA 2007-6800
Author's Title and Affiliation: Ellerbroek: Researcher, Control and Simulation Division, Faculty of Aerospace Engineering, Delft University of Technology, Kluyverweg 1, 2629 HS Delft, the Netherlands
Stroosma: Researcher, Aerospace Engineering, SIMONA, Delft University of Technology, Kluyverweg 1, 2629 HS Delft, the Netherlands
Mulder and van Paassen: Associate Professor, Control and Simulation Division, Faculty of Aerospace Engineering, Delft University of Technology, Kluyverweg 1, 2629 HS Delft, the Netherlands
Abstract: A set of experiments has been conducted to investigate the relative effect of translational and rotational motion cues on pilot performance. Two helicopter yaw control tasks were performed on the SIMONA Research Simulator; a yaw capture task, and a target tracking task with simulated turbulence. The yaw capture task was a repetition of a task performed previously by Schroeder and Grant at two different simulator facilities. Shaping filters and added delays were used to match simulator characteristics with previous experiments. In contrast to Schroeder and Grant's conclusions, results from the current study show more equal contributions of yaw and sway motion on performance and subjective simulator motion fidelity. Analyses of the different vestibular cues using multi-loop pilot models, estimated from measurement data from the target tracking task, also indicate comparable utilization of the yaw and sway motion cues.

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Reference Type: Report
Author: Emery, Cathy; Robin, Jerry; Knipling, Ronald; Finn, Ron; Fieger, Stephen
Year: 1999
Title: Research design: Validation of simulation technology in the training, testing, and licensing of tractor-trailer drivers
Type: Final Report
Report Number: FHWA-MC-99-060
Author's Title and Affiliation: Science Applications International Corporation, Turner-Fairbank Highway Research Center, 6300 Georgetown Pike, McLean, VA 22101
Number of Pages: 113
Keywords: driving simulator, truck driver training, heavy trucks, commercial motor vehicles, tractor-trailers
Abstract: The Federal Highway Administration (FHWA), Office of Motor Carrier Highway Safety (OMCHS) is conducting research to validate the use of low-to mid-cost simulator for commercial driver training, testing and licensing. The primary purpose of the study is to examine how simulator technology, as compared to conventional methods, may facilitate and enhance tractor-trailer driver performance. This report details the proposed research design to conduct the empirical simulator validation study.
The research design consists of three distinct parts. Part 1 addresses the forward transfer of training for entry-level drivers. Part 2 is an assessment of the advanced capabilities of the test simulator. Part 3 is a longitudinal study of the drivers that have successfully completed either the truck-based or simulator-based driver training program and have gone on to earn their Commercial Drivers License.

A previous OMCHS report titled, "Commercial Motor Vehicle Simulation Technology To Improve Driver Training, Testing and Licensing Methods Final Report - April 1996," evaluated truck driving simulators in the United States and Europe. The report indicated that truck driving simulation was sufficiently mature and recommended that FHWA validate this technology. The Digitran SafeDrive 1000 was recommended as the test bed for the follow-on validation study. A copy of the report can be obtained by contacting the National Technical Information Service (703-605-6000 or 1-800-553-6847) and referencing NTIS Publication Number PB96-183405.
The validation study will commence in FY1999. It will start with a reassessment of the commercial marketplace to assure the simulator selected as the test bed for the study reflects the most up-to-date information and best meets the needs of OMCHS.

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Reference Type: Electronic Article
Author: Environmental Tectonics Corporation (ETC)
Year: 2001
Title: Environmental Tectonics Corporation announces the development of a tactical flight simulation centrifuge
Volume: 2006
Issue: Sept. 6
Keywords: G Tactical Flight Simulator (G-FET II TFS), upset recovery training (URT)
Abstract: Environmental Tectonics Corporation (Amex: ETC) today announced its Sustained G Tactical Flight Simulator, the G-FET II TFS
URL: http://www.etcusa.com/corp/pressreleases/2001/NR121301.htm
Access Date: December 13

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Reference Type: Electronic Article
Author: Environmental Tectonics Corporation (ETC)
Year: 2001
Title: ETC's centrifuge trains 20,000th pilot at Holloman AFB, NM
Issue: March 7
Label: Press release
Keywords: G-Induced Loss of Consciousness (G-LOC), High-G, unusual attitudes, centrifuge, upset recovery training (URT)
URL: http://www.etcusa.com/corp/pressreleases/2001/NR030701.htm
Access Date: October 25, 2005

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Reference Type: Conference Proceedings
Author: Ercole, Anthony V.; Cardullo, Frank M.; Zaychik, Kirill; Kelly, Lon; Houck, Jacob
Year of Conference: 2009
Title: Motion cueing algorithm modification for improved turbulence simulation
Conference Name: AIAA Modeling and Simulation Technologies Conference
Conference Location: Chicago, IL
Publisher: American Institute of Aeronautics and Astronautics (AIAA)
Pages: 1-15
Date: Aug. 10-13
Electronic Resource Number: AIAA-2009-6247
Author's Title and Affiliation: Ercole: Graduate Student, Man-Machine Systems Laboratory, Department of Mechanical Engineering, SUNY Binghamton, Binghamton, NY
Cardullo: Professor, Man-Machine Systems Laboratory, Department of Mechanical Engineering, SUNY Binghamton, Binghamton, NY

Zaychik: PhD Candidate, Man-Machine Systems Laboratory, Department of Mechanical Engineering, SUNY Binghamton, Binghamton, NY
Kelly: Software Engineer, Simulation and Development Branch, Unisys Corporation, Hampton, VA
Houck: Distinguished Research Associate, Simulation Development and Analysis Branch, NASA LaRC, Hampton, VA
Keywords: turbulence cueing
Abstract: Atmospheric turbulence cueing produced by flight simulator motion systems has been less than satisfactory because the turbulence profiles have been attenuated by the motion cueing algorithms. Cardullo and Ellor initially addressed this problem by directly porting the turbulence model output to the motion system. Reid and Robinson addressed the problem by employing a parallel aircraft model, which is only stimulated by the turbulence inputs and adding a filter specially designed to pass the higher turbulence frequencies.
There have been advances in motion cueing algorithm development at the Man-Machine Systems Laboratory at SUNY Binghamton. In particular, the system used to generate turbulence cues has been studied. The Reid approach, implemented by Telban and Cardullo, was employed to augment the optimal motion cueing algorithm installed at the NASA LaRC Simulation Laboratory, driving the Visual Motion Simulator.
In this implementation, the output of the primary flight channel was added to the output of the turbulence channel and then sent through a non-linear cueing filter. The cueing filter is an adaptive filter; therefore, it is not desirable for the output of the turbulence channel to be augmented by this type of filter. The likelihood of the signal becoming divergent was also an issue in this design.
After testing on-site it became apparent that the architecture of the turbulence algorithm was generating unacceptable cues. As mentioned above, this cueing algorithm comprised a filter that was designed to operate at low bandwidth. Therefore, the turbulence was also filtered, augmenting the cues generated by the model. If any filtering is to be done to the turbulence, it will utilize a filter with a much higher bandwidth, above the frequencies produced by the aircraft response to turbulence.
The authors have developed an implementation wherein only the signal from the primary flight channel passes through the nonlinear cueing filter. This paper discusses three new algorithms. Testing shows that the new methods provide the pilot with a more realistic sensation of turbulence; the cues are not attenuated by [the] algorithm. Results of offline testing show the credibility of the models. Offline test verification was based primarily on the evaluation of the power spectral density of the outputs and the time response.

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Reference Type: Book Section
Author: Ercoline, William R.; DeVilbiss, Carita A.; Evans, Richard H.
Year: 2004
Title: Flight displays I: Head-down display topics for spatial orientation
Editor: Previc, Fred H.; Ercoline, William R.
Book Title: Spatial Disorientation in Aviation
City: Reston, VA
Publisher: American Institute of Aeronautics and Astronautics (AIAA)
Series Volume: 203
Pages: 370-449
Chapter: 9
Series Editor: Zarchan, Paul
Series Title: Progress in Astronautics and Aeronautics
Author's Title and Affiliation: Ercoline & Evans: General Dynamics Advanced Information Systems, San Antonio, TX
DeVilbliss: Army Research Laboratory, Ft. Sam Houston, TX
Previc: Northrop Grumman Information Technology, San Antonio, TX
Zarchan: MIT Lincoln Laboratory, Lexington, MA
Keywords: spatial disorientation, head-up displays, upset recovery training (URT)

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Reference Type: Journal Article
Author: Eriksson, Lars; Hofsten, Claes von
Year: 2005
Title: Effects of visual flow display of flight maneuvers on perceived spatial orientation
Journal: Human Factors
Volume: 47
Issue: 2
Pages: 378-393
Date: Jun
Number of Pages: 16
Accession Number: 01013401
Keywords: aircraft accidents, aircraft pilotage, aviation safety, experiments, flight simulators, visual flight, flight displays, head-tracker system, postural control, spatial disorientation, visual flow
Abstract: Spatial disorientation during flight is among the causes of aircraft mishaps with aircraft and pilot losses. In this study, postural responses were used for indicating relative effectiveness of wide-angle visual flow display characteristics in determining perceived spatial orientation. The general experimental setup included a 150 degree x 34 degree wide-field display showing flight over computer-generated ground with horizon. Postural responses were measured by means of a head-tracker system while three integrated computer monitors displayed a wide field of view of ground and horizon as if viewed from a rolling aircraft. Researchers designed two experiments, with 16 participants in each, to investigate the effects of visual flow, display exclusions in the central visual field, and display extensions into the visual periphery. The results of both experiments were quite consistent. The flight-maneuver-adapted flow was effective in inducing postural sway with the inclusion of visual flow of forward ego motion in roll maneuvers. Compared with the full view, up to 20 degrees x 20 degrees central field omission either did not reduce the effect or reduced the effect frequently, but only moderately. Limiting the display area to 45 degrees in the horizontal dimension siginificantly reduced display effectiveness, whereas a 105 degree area did not, compared with the full view. By using postural responses as indications of visual display resonance with the spatial orientation mechanism, applications of this research can include the design of an interface that integrates flight-adapted visual flow to reduce pilot spatial disorientation. This study represents the first steps towards an interface design that integrates visual flow.
Name of Database: TRIS Online

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Reference Type: Magazine Article
Author: Erwin, Sandra I.
Year: 2000
Title: $65K flight simulator draws skepticism from military buyers
Magazine: National Defense Magazine
Date: November
Type of Article: Online Magazine Article
Number of Pages: 3
URL: http://www.nationaldefensemagazine.org/ARCHIVE/2000/NOVEMBER/Pages/65K_Flight7161.aspx

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Reference Type: Magazine Article
Author: Erwin, Sandra I.
Year: 2000
Title: Navy fine-tuning acquisition strategy for flight simulators
Magazine: National Defense Magazine
Volume: 2006
Issue Number: Sept. 6
Date: November 2000
Type of Article: Online article
Number of Pages: 7

Abstract: Recent investments by the U.S. Navy in flight training technologies denote a focus on systems that are easy to use and to transport to remote locations around the world, even on ships.
URL: http://www.nationaldefensemagazine.org/ARCHIVE/2000/NOVEMBER/Pages/Navy_Fine-Tuning7182.aspx

*****

Reference Type: Magazine Article
Author: Erwin, Sandra I.
Year: 2001
Title: Aviation enthusiasts ponder: How good are PC simulators?
Magazine: National Defense Magazine
Volume: 2006
Issue Number: Sept. 6
Type of Article: Online article
Number of Pages: 3
URL:
http://www.nationaldefensemagazine.org/archive/2001/November/Pages/Aviation_Enthusiasts4169.aspx

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Reference Type: Conference Proceedings
Author: Estock, J. L.; Alexander, A. L.; Gildea, K. M.; Nash, M.; Blueggel, B.
Year of Conference: 2006
Title: A model-based approach to simulator fidelity and training effectiveness
Conference Name: Interservice/Industry Training, Simulation, and Education Conference (I/ITSEC)
Conference Location: Orlando, FL
Date: December 4-6
Electronic Resource Number: Paper No. 2794
Author's Title and Affiliation: Estock, Alexander, and Gildea: Aptima, Inc., Woburn, MA
Captain Nash and 2nd Lieutenant Blueggel: Air Force Research Lab, Mesa, AZ
Number of Pages: 9
Abstract: Although there is a commonly held belief that high-fidelity simulators provide a high degree of transfer, some evidence indicates that lower-fidelity simulators can provide benefits without the added expense and complexity of high-fidelity simulators (Wickens & Hollands, 2000). The civilian flight simulator market contains inexpensive systems for training procedures and operations. A plethora of force-cueing devices can augment the lower-fidelity simulators. However, the effect of force-cueing devices on performance and training is a heavily debated topic (e.g., Heintzman, 1997). Furthermore, the available information regarding the impact of fidelity on training effectiveness is documented in a disparate and fragmented literature. The ability to assemble this information in a common location and to establish quantitative, predictive relationships between simulator fidelity and training effectiveness would greatly enhance the value of training programs that utilize simulators to train operators.
In this paper, we will describe the Relating Effective Learning to Attributes of the Training Environment (RELATE) approach, a process designed and applied in the Performance Effects Related to FORce-cueing Manipulations (PERFORM) project. The purpose of the RELATE approach is to establish quantitative, predictive relationships between the attributes of a training environment and training effectiveness. In the PERFORM project, the training attribute of interest is simulator fidelity. The RELATE approach consists of six steps: (1) identifying the relevant dimensions of simulator fidelity, (2) identifying the knowledge and skills (K&S) necessary in the specific domain, (3) determining whether a relationship exists between the fidelity dimensions and the K&S, (4) developing functions that define the relationships between fidelity dimensions and K&S, (5) developing algorithms that predict training effectiveness, and (6) empirically validating the functions and algorithms. We will walk through the steps as they were applied in the PERFORM project, which aimed at determining the level of fidelity required for effective air-to-air combat training in F-16 simulators.
Author Address: jestock@aptima.com; aalexander@aptima.com; kgildea@aptima.com; michelle.nash@mesa.afmc.af.mil; brenda.blueggel@mesa.afmc.af.mil

Reference Type: Conference Proceedings
Author: Estock, Jamie L.; Alexander, Amy L.; Stelzer, Emily M.; Baughman, Kathryn
Year of Conference: 2007
Title: Impact of visual scene field of view on F-16 pilot performance
Conference Name: Human Factors and Ergonomics Society 51st Annual Meeting
Conference Location: Baltimore, MD
Publisher: Human Factors and Ergonomics Society (HFES)
Pages: 75-79
Date: October 1-5
Author's Title and Affiliation: Aptima, Inc.
Abstract: The tremendous expense and inherent dangers of training in the aircraft have led to the increased use of simulators for practicing and maintaining air combat skills[.] However, the advantages and disadvantages of using high or low-fidelity simulators for such training must be specified. An experiment was conducted to examine the in-simulator performance differences between pilots flying lower-fidelity simulators compared to higher-fidelity simulators. The primary difference between the two simulators is the visual scene field-of-view. Sixteen U.S. Air Force F-16 pilots flew standard training missions as an integrated team of four (a "four-ship") with two pilots flying the high-fidelity simulators and two pilots flying the lower-fidelity simulators. Various subjective and objective measures were collected to assess the pilots' ability to maintain a briefed formation. Overall, the results suggest that pilots who practice four-ship employment in the lower-fidelity simulators can perform at the same level as those who practice in the high-fidelity simulators. Future analyses should be conducted to examine the impact of simulator fidelity on other air combat skills and on training effectiveness.

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Reference Type: Conference Paper
Author: Faconti, Victor
Year: 2000
Title: The instructor/operator station: Where do we go from here?
Conference Name: Flight Simulation - The Next Decade
Conference Location: London, UK
Publisher: Royal Aeronautical Society (RAeS)
Date: May 10-12
Author's Title and Affiliation: The Boeing Company, Mesa, Arizona
Number of Pages: 9
Abstract: The instructor/operator station (IOS) has undergone a number of evolutionary changes since the use of flight simulators for pilot training became commonplace. This evolution has been driven both by the increasing role of the training simulator in providing an adjunct to the real-world system as a training tool and the major advance in enabling technologies. In 1979 I presented a paper to the RAeS conference on "Fifty Years of Flight Simulation" and in that, I outlined the development of instructor stations from the rudimentary "crabs" crawling on paper maps to the most modern CRT-based system, at that time, used on the B-52 Weapon System Trainer (WST). Since the advances in technology have given us a better picture on CRTs (and now LCDs) and several orders of magnitude increase in capabilities and features.
In the meantime, flight training philosophy has itself undergone a revolution in the approach to training methodology. Most major military planners now think in terms of team training as opposed to individual or even crew training. The civil aviation industry is looking at the benefit of "real-world" training where other elements in the scenario are other operators also training in the same problem. It is clear that team training will be the standard in both military and civilian flight simulator training as we move into the 21st century.

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Reference Type: Magazine Article
Author: Facsar, Fanny
Year: 2007
Title: Interview mit Lufthansa-Pilot Burkhard Kruse: 'Wir hatten Wind mit 300 km/hr'
Magazine: Spiegel Online
Date: January 19
Notes: This article is in German.
URL: http://www.spiegel.de/reise/aktuell/0,1518,460907,00.html
Access Date: 1/19/2007 4:13pm

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Reference Type: Report
Author: Feddersen, W. E.
Year: 1962
Title: The role of motion information and its contribution to simulator validity
Institution: Bell Helicopter Textron Inc.
Document Number: AD 281 855
Date: April
Report Number: D228-429-001
Author's Title and Affiliation: Bell Helicopter Company
Recipient's Title and Affiliation: Army-Navy Instrumentation Program (ANIP), U.S. Office of Naval Research
Abstract: The use of a motion simulator in the evaluation and testing of those display and instrumentation concepts which are central to the objectives of the Army-Navy Instrumentation Program (ANIP) poses the same question that is asked of any testing device; namely, to what extent does the device allow a valid evaluation of the developments under consideration. The ultimate in validity in such a situation would be achieved when operator behavior in the simulator corresponds precisely to control

behavior in the system being simulated which, in this case, is a helicopter in all of its different flight modes. Since it is unrealistic to expect exact behavior correspondence in the two situations the task is one of determining the extent or degree of approximation.
This report summarizes the results of a series of three investigations, both simulator and flight test, designed to determine the relative proficiency allowed by motion information in the simulator in a hovering flight mode and, secondly, to determine with appropriate measures the degree to which control behavior in the helicopter is approximated by behavior in the simulator when the tasks are equivalent.
The proficiency results are reported in terms of integrated absolute error scores about the various axes defining the hovering task, and the behavioral data. That is, the data indicative of the way in which the helicopter and simulator are controlled by the operator, are presented in the form of auto-correlation functions.

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Reference Type: Report
Author: Federal Aviation Administration (FAA)
Title: GPS air carrier training program
Type: Advisory Circular Draft
Report Number: 120-XX
Keywords: GPS navigation systems
Notes: As of 2/22/07, the web page was no longer available.
URL:
http://www.airweb.faa.gov/Regulatory_and_Guidance_Library/rgAdvisoryCircular.nsf/MainFrame?OpenFrameSet

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Reference Type: Legal Rule or Regulation
Author: Federal Aviation Administration (FAA)
Year: 1977
Title: Appendix F to Part 121 - Proficiency Check Requirements
Rule Number: 14 CFR § 121

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Reference Type: Legal Rule or Regulation
Author: Federal Aviation Administration (FAA)
Year: 1988
Title: Appendix E to Part 121 - Flight Training Requirements
Rule Number: 14 CFR § 121

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Reference Type: Legal Rule or Regulation
Author: Federal Aviation Administration (FAA)
Year: 1990
Title: Low-Altitude Windshear System Equipment Requirements
Rule Number: 14 CFR § 121.358

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Reference Type: Legal Rule or Regulation
Author: Federal Aviation Administration (FAA)
Year: 1995
Title: Code of Federal Regulations, Title 14, Part 119 - Certification: Air Carriers and Commercial Operators

Rule Number: 60
Pages: 65913-65925
Date of Code Edition: December 20

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Reference Type: Web Page
Author: Federal Aviation Administration (FAA)
Year: 1995
Title: Federal Aviation Regulations (FAR) 61--Certification: Pilots, flight instructors, and ground instructors--Subpart A--General
Series Editor: Balloon Life
Access Year: 2006
Access Date: Sept. 18
Keywords: FAR 61
URL: http://www.balloonlife.com/publications/balloon_life/9509/part61sa.htm

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Reference Type: Book Section
Author: Federal Aviation Administration (FAA)
Year: 1995
Title: SFAR No. 58
Editor: Spanitz, Jackie
Book Title: FAR Flight Crew; Federal Aviation Regulations; Parts 25, 63 & 121
City: Renton, WA
Publisher: Aviation Supplies and Academics, Inc. (ASA)
Pages: 208-212
Number of Pages: 5
Call Number: ASA-95-FAR-FC
ISBN 1-56027-206-6

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Reference Type: Report
Author: Federal Aviation Administration (FAA)
Year: 1996
Title: Assessment of PC-based aviation training devices
Institution: Federal Aviation Administration (FAA), Civil Aeromedical Institute
Date: September
Type: FAA research report
Report Number: ARR161-6
Number of Pages: 6

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Reference Type: Newspaper Article
Reporter: Federal Aviation Administration (FAA)
Year: 1997
Title: FAA one level of safety commuter rule deadline marks safety improvements, decline in accident rate
Newspaper: FAA News
City: Washington, DC
Pages: APA 44-97
Issue Date: March 21
Number of Pages: 3

Keywords: commuter rule, safety standards
Abstract: The Federal Aviation Administration (FAA) today announced that the aviation industry has successfully implemented the Commuter Rule which set new safety standards for scheduled airlines operating aircraft with 10 passenger seats or more. This rule is the central element in the Clinton Administration's single level of safety program to hold all scheduled air carriers to the same high safety standards.

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Reference Type: Report
Author: Federal Aviation Administration (FAA)
Year: 1998
Title: Authorization for use of personal computer-based aviation training devices under the provisions of Title 14 of the Code of Federal Regulations (14 CFR) Parts 61 and 141
Series Title: Flight Standards Information Bulletin (FSIB) for General Aviation (FSGA)
Institution: FSGA
Date: May 26
Report Number: FSGA 98-02
Number of Pages: 3
Keywords: Personal Computer-based Aviation Training Devices (PCATDs), qualification and approval, guidelines
Abstract: This bulletin contains information and guidelines to permit aviation safety inspectors (ASI) to authorize the use of personal computer-based aviation training devices (PTCAD), qualified and approved in accordance with Advisory Circular (AC) 61-126, Qualification and Approval of Personal Computer-Based Aviation Training Devices, toward satisfying the instrument rating flight training requirements of Title 14 of the Code of Federal Regulations (14 CFR) parts 61 and 141, under the Administrator's authority for the approval of these devices under section 61.4 (c).
Notes: On 9/30/09, the URL no longer works.
URL:
http://www.faa.gov/safety/programs_initiatives/aircraft_aviation/nsp/flight_training/qualification_process/media/fsga9802.txt

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Reference Type: Report
Author: Federal Aviation Administration (FAA)
Year: 2000
Title: Airworthiness Directive Boeing model 737 series airplanes
Series Title: Airworthiness Directive
Report Number: AD 2000-22-02 R1
Keywords: B737, rudder, upset recovery training (URT)
Abstract: This document corrects information in an existing airworthiness directive (AD) that applies to all Boeing Model 737 series airplanes. That AD supersedes AD 99-05-15, amendment 39-11063, to require revising the FAA-approved Airplane Flight Manual (AFM) procedure in the existing AD to simplify the instructions for correcting a jammed or restricted flight control condition. This document corrects the format for certain AFM material described in that AD. This correction is necessary to ensure that the flightcrew is aware of certain critical recall items in the AFM procedure that are necessary to address a condition involving a jammed or restricted rudder.
URL:
http://www.airweb.faa.gov/Regulatory_and_Guidance_Library/rgAD.nsf/0/8F22812761F67328862569AB006EB9E5?OpenDocument

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Reference Type: Report
Author: Federal Aviation Administration (FAA)
Year: 2000
Title: B737 uncommanded rudder
Series Title: Joint Flight Standards for Air Transportation (FSAT) and General Aviation (FSGA)
Document Number: FSAT 00-16 and FSGA 00-09A
Report Number: AD 2000-22-02
Keywords: B737, rudder, upset recovery training (URT)
Abstract: (from 2. Background) A series of accidents and incidents involving Boeing 737 airplanes brought the airplane's rudder system under the scrutiny of the NTSB and other organizations involved in aviation safety.
Notes: The URL no longer works (9/30/09).
URL: http://www.faa.gov/library/manuals/examiners_inspectors/8700/fsga/media/fsga0009.doc

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Reference Type: Federal Aviaiton Regulations (FAR)
Author: Federal Aviation Administration (FAA)
Year: 2000
Title: FAR-121-Appendix H to Part 121: Advanced simulation plan
URL:
http://www.airweb.faa.gov/Regulatory_and_Guidance_Library/rgFAR.nsf/MainFrame?OpenFrameSet

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Reference Type: Legal Rule or Regulation
Author: Federal Aviation Administration (FAA)
Year: 2001
Title: Airworthiness Standards: Transport Category Airplanes
Rule Number: 14 CFR § 25.1585

*****

Reference Type: Web Page
Author: Federal Aviation Administration (FAA)
Year: 2002
Title: 14 CFR Part 1: Part 1--Definitions and abbreviations
Access Year: 2006
Access Date: Sept. 6
Last Update Date: January 1, 2002
Number of Pages: 18
URL: http://www.access.gpo.gov/nara/cfr/waisidx_02/14cfr1_02.html

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Reference Type: Web Page
Author: Federal Aviation Administration (FAA)
Year: 2005
Title: Flight Standards Service (AFS)
Access Year: 2006
Access Date: Sept. 6
Last Update Date: November 21, 2006
Abstract: The Flight Standards Service promotes safe air transportation by setting the standards for certification and oversight of airmen, air operators, air agencies, and designees. We also promote safety of flight of civil aircraft and air commerce by:
Accomplishing certification, inspection, surveillance, investigation, and enforcement

Setting regulations and standards
Managing the system for registration of civil aircraft and all airmen records
Flight Standards District Offices (FSDO)
Overview Video
Customer Satisfaction Industry Survey (CSIS)
URL: http://www.faa.gov/about/office_org/headquarters_offices/avs/offices/afs/
Author Address: Federal Aviation Administration, Flight Standards Service, Room 821, 800 Independence Avenue, S.W., Washington, DC 20591
Phone: (202) 267-8237, Fax: (202) 267-5230

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Reference Type: Web Page
Author: Federal Aviation Administration (FAA)
Year: 2006
Title: 14 CFR Part 141- Pilot schools
Publisher: Federal Aviation Administration
Access Year: 2006
Access Date: Sept. 6
Last Update Date: August 7, 2006
Number of Pages: 5
URL: http://ecfr.gpoaccess.gov/cgi/t/text/text-idx?c=ecfr&sid=f4866fb822b1dbcc615562678afed80b&rgn=div5&view=text&node=14:3.0.1.1.2&idno=14

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Reference Type: Conference Proceedings
Author: Federal Aviation Administration (FAA)
Year of Conference: 2006
Title: The current status & future of voluntary flight safety programs
Conference Name: Shared Visions in Aviation Safety Conference
Conference Location: Denver, CO
Date: April 18-20
Abstract: Topics / Speakers/Presenters:
1. Threat & Error Management (TEM) and the Line Operations Safety Audit (LOSA) James Klinect, Ph.D. Univ. of Texas, The LOSA Collaborative
2. Using LOSA Data Capt. Dave Bair, Frontier Airlines
3. How Alaska Uses LOSA Data Robert Graves, Alaska Airlines
4. LOSA Capt. Bruce Tesmer, Continental Airlines
5. Aviation Safety Action Program (ASAP) 101 Kevin Kelley, Aviation Safety Inspector, Voluntary Safety Programs-AFS-230
6. United Parcel Service ASAP Capt. Brendan Fahy, ASAP Coordinator, UPS; Capt. Terry Kom, UPS Airlines; O. T. Blankenship, Aviation Safety Inspector, Kentucky FSDO
7. OSAP United Flight Attendant Safety Awareness Program Lessons Learned Jack O'Brien, Manager Flight Safety-Onboard, United Airlines
8. Flight Operations Quality Assurance (FOQA) - Program Overview and Technology Update Capt. Doug Diehl, Director, Flight Operations Safety, Frontier Airlines
9. Advanced Qualification Program (AQP) 101 Doug Farrow, Ph.D., Instructional Specialist, FAA; Ron Barry, Aviation Safety Inspector, FAA
10. AQP Document Templates for Airlines Transitioning to AQP Ron Barry, Aviation Safety Inspector, FAA Contact presenter directly for information on presentation.
11. Introduction to the Conference Tom Longridge, Ph.D., Manager, Voluntary Safety Programs-AFS-230, FAA
12. Aviation Safety Information Sharing Efforts Terry McVenes, Executive Air Safety Chairman, Air Line Pilot Association
13. FAA Shared Vision of Aviation Safety Mont Smith, Director, Safety, Air Transport Association

14. The Role of a Just Culture in Implementing Safety Management Systems David Marx, President, Outcome Engineering
15. Safety Management from the Field: A European Regulator Perspective about Old & New Developments Stéphane DEHARVENGT, Head of Human Factors Program and Safety Initiatives, DGAC-F/DAST/SEA
16. ASAP Event Risk Analysis and ATOS Integration Frank Raymond, Manager, ASAP Programs, Alaska Airlines
17. Distributed National Airline Safety Archives Update Capt. Robert E. Lynch, Director National Aviation Safety Archives, Battelle
18. LOSA-Based Line Check Program Capt Bob Steider, B777 Assistant Fleet Manager, Continental Airlines
19. Recreation of an ASAP/ASRS Event for use in AQP Line Oriented Evaluations Standardization and Crew Resource Management Facilitation Roger Coleman, Manager, Human Factors and Safety Training, American Airlines
20. SNL Top Gun video Roger Coleman, Manager, Human Factors and Safety Training, American Airlines
21. Threat and Error Management as a Framework for ASAP Data Collection Michelle Harper, University of Texas at Austin Human Factors Research Project
22. How to Train for Automation - Results from Research & Tips for Application in the Field Florian Jentsch, U. of Central Florida; Deborah Boehm-Davis, George Mason U.; Elizabeth Lyall, Research Integrations, Inc.
23. Steering Committee for Distance Learning - Draft AC and 8400.10 Handbook Recommendations OJ Treadway, Manager, Flight Training Development, American Airlines
24. IFQASys ASAP Overview and Demonstration David Neu, IFQASys Program Manager, UTRS, Inc.; Arend van der Veen, IFQASys Team Member, UTRS, Inc.
25. System Safety Integration with Voluntary Programs Jim Kent, System Safety Manager, UPS
26. An Integrated Model for Flight Operations Monitoring Capt. John Scully, Line Assistance Mgr/Training & Flt Ops, Airbus
27. FOQA - Examples of Good and Bad practice, from operators Large and Small Dave Jesse, President, Flight Data Services Inc.
28. ATS International Services to Airlines with a focus on Flight Data Monitoring Services and Operations Manuals Dominique LECOMTE, Business Development ATS International Groupe AEROCONSEIL 2
29. QIT Aviation Safety Audit Manager - An affordable program to help you implement IEP and LOSA audits Logan Luo, Senior Consultant, QIT Consulting, Inc.
30. The Need for Quality Aviation Safety Graduates: An Educational Challenge Thomas R. Weitzel, Ed.D., Associate Professor, Embry-Riddle Aeronautical University
31. Aviation Safety Reporting System (ASRS): An Update on Safety Contributions Linda Connell, Director, Aviation Safety Reporting System, NASA
32. FOQA Review Board (FRB) - A New Concept Using a Collective Approach to FDR Based Decision-Making Jean-Pierre Dagon, Director Corporate Safety, AirTran Airways
33. Web-based Voluntary Disclosure Reporting Program for Operators & FAA Inspectors Scott Crosier, Aviation Safety Inspector, FAA
34. System Safety: Industry Problems and Concerns Steven C. McNeely, Manager, Internal Evaluations/Safety/ISO, Jet Solutions, LLC
35. Safety Action Program in a Flight Attendant Environment Valerie Walker, MEC Safety Vice-Chair, United, Association of Flight Attendants-CWA; Helen Zienkievicz, Manager, Health, Safety and Security, United Airlines
36. Update on SMS and its Relationship to Voluntary Safety Programs Don Arendt, Manager, Flight Standards Safety and Analysis Center (FSAIC), FAA
37. Integrating Safety Programs for Safety Action Chris Glaeser, Director of Safety, Northwest Airlines
38. Integrated Analysis in FOQA, ASAP, & AQP at Jet Blue Airways Tim Tatem, FOQA Manager, JetBlue Airways
39. The Air Traffic Organization - A Partner in Safety Management Paul Erway, Air Traffic Organization, FAA
40. Closing Remarks Tom Longridge, Ph.D., Manager, Voluntary Safety Programs-AFS-230, FAA

Reference Type: Web Page
Author: Federal Aviation Administration (FAA)
Year: 2006
Title: FAA industry training standards (FITS)
Access Year: 2006
Access Date: Sept. 6
Last Update Date: February 22, 2006
Type of Medium: Website
Abstract: (taken from Program Plan Executive Summary) The FITS program is under the Safer Skies program and compliant with Challenge 2000 and OMB Circular A-119, Federal Participation in the Development and Use of Voluntary Consensus Standards and in Conformity Assessment Activities. The FITS program is a collaboration of FAA, industry (manufacturers, training providers, universities, insurance companies, trade associations, etc) and the General Aviation Center of Excellence which seeks an evolutionary approach to change that is responsive to the pace of development in the general aviation community. The FITS program will work to develop standards that comply with the flexibility of the current rules, and regulations.
URL: http://www.faa.gov/education_research/training/fits/

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Reference Type: Legal Rule or Regulation
Author: Federal Aviation Administration (FAA)
Year: 2007, September 13
Title: Order 8900.1 Flight Standards Information Management System (FSIMS)
Notes: Initiated by AFS-1
URL: http://fsims.faa.gov

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Reference Type: Legal Rule or Regulation
Author: Federal Aviation Administration (FAA)
Year: 2008, May 30
Title: Flight Simulation Training Device Initial and Continuing Qualification and Use; Final Rule (Change 1)
Rule Number: 14 Code of Federal Regulations Part 60

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Reference Type: Report
Author: Federal Aviation Administration (FAA)
Year: 2010
Title: Answering the call to action on airline safety and pilot training
Institution: Federal Aviation Administration (FAA)
Pages: 1-201
Date: January
Number of Pages: 201

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Reference Type: Government Document
Author: Federal Aviation Administration (FAA)
Year: 2010
Title: New pilot certification requirements for air carrier operations
Department: Department of Trasportation (DOT), Federal Aviation Administration (FAA)
Pages: 1-12
Number of Pages: 12

Reference Type: Magazine Article
Author: Fiorino, Frances
Year: 1997
Title: Primary training-time for a proficiency check
Magazine: Aviation Week & Space Technology
Volume: 22/29
Pages: 100
Date: December
Number of Pages: 1
Keywords: training, experience level, pilot demand

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Reference Type: Magazine Article
Author: Fiorino, Frances
Year: 2001
Title: Physiology training aims to reduce civil mishaps
Magazine: Aviation Week & Space Technology
Date: November 26
Keywords: upset recovery training (URT), physiology training
Abstract: For safety's sake, flight physiology training is being pushed in the general aviation sector, which will soon replace the military as the primary source for airline pilots.

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Reference Type: Magazine Article
Author: Fiorino, Frances
Year: 2002
Title: Delta upset training founded on simplicity
Magazine: Aviation Week & Space Technology
Volume: 157
Issue Number: 9
Date: August 26
Keywords: pilots, pilotage, upset recovery training (URT)
Abstract: Focuses on the upset recovery training of pilots at Delta Air Lines. Objectives and principles of training; Definition of upset; Procedures in upset recovery.

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Reference Type: Magazine Article
Author: Fiorino, Frances
Year: 2002
Title: Upset recovery aims for g-force realism
Magazine: Aviation Week & Space Technology
Volume: 157
Issue Number: 23
Date: December 2
Author's Title and Affiliation: New York
Keywords: air pilots, flight simulators, upset recovery training (URT), g-force
Abstract: Reports on the introduction of the first phase of an upset recovery training program that provides in-flight simulation training opportunities to pilots. Core of the training program; Need for a realistic upset recovery training program; Efforts to develop skill sets related to understanding of angle of attacks; Kinds of upsets taught at the training; Details on the basic and advanced level of training sessions.

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Reference Type: Magazine Article
Author: Fiorino, Frances
Year: 2006
Title: Fighting human error
Magazine: Aviation Week & Space Technology
Pages: 47-49
Date: December 4
Type of Article: section on Simulation and Training
Abstract: Training program targets 'small cracks in personal airmanship armor' that compromise safety.
Notes: Part of section on Simulation and Training. All articles in this section include:
Fighting human error (F. Fiorino)
Retooling maintenance lessons (L. A. Tegtmeier)
Getting upset (E. H. Phillips)
A little competition (J. C. Anselmo)
Ready, VLJet, go (F. Fiorino)

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Reference Type: Magazine Article
Author: Fiorino, Frances
Year: 2006
Title: Ready, VLJet, go
Magazine: Aviation Week & Space Technology
Pages: 54
Date: December 4
Type of Article: part of section on Simulation and Training
Abstract: Embraer, CAE to offer Phenom 100/300 training for flight and ground crews.
Notes: Part of section on Simulation and Training. All articles in this section include:
Fighting human error (F. Fiorino)
Retooling maintenance lessons (L. A. Tegtmeier)
Getting upset (E. H. Phillips)
A little competition (J. C. Anselmo)
Ready, VLJet, go (F. Fiorino)

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Reference Type: Conference Paper
Author: Flach, John M.
Year: 1995
Title: Maintaining situation awareness when stalking cognition in the wild
Conference Name: International Conference on Experimental Analysis and Measurement of Situation Awareness
Conference Location: Embry-Riddle Aeronautical University, Daytona, FL
Author's Title and Affiliation: Psychology Department, Wright State University, Dayton, OH
Number of Pages: 10
Keywords: situation awareness, confirmation bias, hindsight bias, unified field theory
Abstract: The term "situation awareness" originated with tactical fighter pilots as they attempted to articulate the difficulties of managing the complex information processing demands of air combat. The term more recently has been embraced by the human factors community to define a domain of research whose goal is to study cognition as it occurs in complex, dynamic work environments. Other examples include modern medicine and chemical process control. It might also be argued that *science* is a complex, dynamic work environment (although the time constraints are much longer than even process control). If this is true, then it might be useful to recursively apply the question of situation awareness to the science of situation awareness. What traps in the scientific enterprise might lead to loss of situation awareness? What constitutes good situation awareness on the part of the scientist?

Reference Type: Journal Article
Author: Flach, John M.
Year: 1995
Title: Situation awareness: Proceed with caution
Journal: Human Factors
Volume: 37
Issue: 1
Pages: 149-157
Author's Title and Affiliation: Wright State University, Dayton, Ohio
Number of Pages: 9
Keywords: situation awareness, phenomenon identification
Abstract: Situation awareness (SA) is a relatively new concept that has captured the imagination of the human factors community. The new concept it considered in the light of Benton J. Underwood's discussion about psychological concepts. In particular the distinction between SA as a phenomenon description (Level 2 concept) and SA as a causal agent (Level 3 concept) is discussed. The argument that SA is valuable as a phenomenon description draws attention to the intimate interactions between human environment in determining meaning (or what matters) and reflects an increased appreciation for the intimate coupling between processing stages (e.g., perception, decision, and action) within closed-loop systems. However, I caution against considering SA a causal agent. When SA is considered to be an object within the cognitive agent, there is danger of circular reasoning in which SA is presented as the cause of itself. As a causal explanation, SA is a simple, easy-to-understand wrong answer that, in the end, will be an obstacle to research. As a phenomenon description, SA invites further research to discover causal relationships between the design of human-machine systems and the resulting performance.

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Reference Type: Journal Article
Author: Flach, John M.
Year: 1996
Title: Situation awareness: In search of meaning
Journal: CSERIAC Gateway
Volume: 6
Issue: 6
Author's Title and Affiliation: Wright State University, jflach@desire.wright.edu
Number of Pages: 4
Keywords: situation awareness, context independent situation global assessment technique
Abstract: "What a terrible struggle our field has had just to overcome the nonsense syllable! Decades to discover the 'meaningfulness' of nonsense syllables, and decades more to finally turn away from the seductions of this chimera. Instead of the simplification that Ebbinghaus had hoped for, the nonsense syllable, for generations of researchers, merely screened the central problems of memory from inspection with the methods that Ebbinghaus had bequeathed us." Kinstch (1985, p. 461)
"...results based on meaningless stimuli are themselves meaningless when we attempt to understand how people learn and remember. This is the issue of ecological validity again, saying in essence that our traditional laboratory results do not apply to real-world situations that involve memory for meaningful material." Ashcraft (1994, p. 210)

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Reference Type: Journal Article
Author: Flach, John M.; Hagen, Brent A.; Larish, John F.
Year: 1992
Title: Active regulation of altitude as a function of optical texture
Journal: Perception and Psychophysics
Volume: 51
Issue: 6

Pages: 557-568
Number of Pages: 12
Keywords: altitude, optical texture, optical splay
Abstract: Two empirical studies are reported that examine active regulation of altitude as a function of the type of ground texture. Three ground textures were examined: lines perpendicular to the direction of motion, lines parallel to the direction of motion, and the combination (i.e., square or checkerboard texture). Although subjects only controlled altitude, disturbances were introduced on three axes: vertical, lateral, and fore-aft. The results show a clear advantage for texture parallel to the direction of motion. However, in considering these results in the context of previous research on altitude control, the argument is made that there is no compelling evidence that suggests either parallel (splay) or perpendicular (density) texture is privileged with regard to altitude control. Rather, the most effective display for altitude control will be the one that best isolates the optical activity associated with the changing altitude for the optical activity arising from other sources of disturbance (such as forward locomotion). Such a display will make it easier for the observer to distinguish and respond specifically to the disturbances of altitude.

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Reference Type: Journal Article
Author: Flach, John M.; Riccio, Gary E.; McMillan, Grant R.; Warren, Rik
Year: 1986
Title: Psychophysical methods for equating performance between alternative motion simulators
Journal: Ergonomics
Volume: 29
Issue: 11
Pages: 1423-1438
Author's Title and Affiliation: Flach: University of Illinois at Urbana-Champaign, Engineering Psychology Program
Riccio: Systems Research Laboratories, Inc., Dayton, OH
McMillan & Warren: Armstrong Aerospace Medical Research Laboratory, Wright-Patterson Air Force Base, OH
Number of Pages: 16
Keywords: ALCOGS, RATS, motion simulators, roll-axis flight control tasks, whole-body motion, g-cueing, dynamic seat, psychophysical matching, magnitude estimation, tactile-kinesthetic cueing, motion, simulation
Abstract: Psychophysical matching techniques were employed to equate the subjective experience of motion on two roll-axis motion simulation devices: the RATS, a whole-body motion environment, and the dynamic seat sub-system of the ALCOGS, presenting motion cues through a moving seat-pan. Two psychophysical techniques, cross-modality matching and magnitude estimation, yielded similar results. These results indicated that motion sensitivity increased with roll angular frequency for both simulators. However, the rate of increase at high frequencies was greater for the RATS than for the dynamic seat. These results were used to design a filter for the dynamic seat which enhanced high-frequency signal components. Tests in a roll-axis tracking task showed that performance in a dynamic seat using this filter was both quantitatively (in terms of r.m.s. error) and qualitatively (in terms of frequency characteristics) similar to performance in the whole-body motion environment.

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Reference Type: Journal Article
Author: Fleishman, E. A.; Rich, S.
Year: 1963
Title: Role of kinesthetic and spatial-visual abilities in perceptual-motor learning
Journal: Journal of Experimental Psychology
Volume: 66
Issue: 1
Pages: 6-11

Author's Title and Affiliation: Yale University
Number of Pages: 6
Keywords: "kinesthetic sensitivity," proprioceptive cues, exteroceptive (spatial-visual) cues, perceptual-motor learning
Abstract: Ss were administered a spatial test and a new measure of "kinesthetic sensitivity," and then received extended practice on a Two-Hand Coordination (THC) task. The results confirm the hypothesis that sensitivity to proprioceptive cues is more important later in perceptual-motor learning while sensitivity to exteroceptive (spatial-visual) are more critical earlier in learning. The study extends previous work which showed that abilities which contribute to learning early in practice may be different from those which facilitate later learning.

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Reference Type: Magazine Article
Author: Flight International
Year: 1994
Title: J41 crash probe focuses on training
Magazine: Flight International
Pages: 9
Date: January 19-25
Abstract: The J41, on United Express flight 6291 from Washington DC's Dulles International Airport, with five passengers and three crew aboard, crashed at 23.21 local time while on an autopilot-coupled instrument-landing-system final approach to Port Columbus International Airport in Columbus, Ohio.

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Reference Type: Web Page
Author: Flight Research Training Center
Year: 2005
Title: Upset recovery training study
Last Update Date: July, 2005
Keywords: Flight Research Training Center, loss-of-control, upset recovery training (URT)
Abstract: The Flight Research Training Center, established by the Alliance for Flight Safety Research in Roswell, NM, focuses on improving the safety of commercial air transportation in an effort to reduce the Loss-of-Control accident rate. The Alliance is developing new pilot training methods and technologies to teach pilots how to better cope with upset events that can lead to a Loss-of-Control accident. The primary goals of this program are to conduct research to optimize In-Flight Simulation (IFS) based Upset Recovery Training (URT), such that it meets the needs of the civilian aviation community; to design and develop IFS technology and systems specifically for the URT role; and ultimately, to have a beneficial impact on the Loss-of-Control accident rate.
URL: http://www.flightresearchtraining.org/

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Reference Type: News Release
Author: Flight Safety Foundation (FSF)
Year: 1998
Title: Wide range of strategies for improving aviation safety highlights joint meeting of Flight Safety Foundation, International Federation of Airworthiness and International Air Transport Association
Place Published: Alexandria, VA
Publisher: Flight Safety Foundation
Date: November 19
Abstract: FSF Approach-and-Landing Accident Reduction (ALAR) Task Force's landmark recommendations are among presentations aimed at joint meeting's theme - "Aviation: Making a Safe System Safer."
URL: www.flightsafety.org/news/nr98-17.pdf

Reference Type: Magazine Article
Author: Flight Safety Foundation Editorial Staff
Year: 2003
Title: More than half of large commercial jet accidents in 2002 occurred during approach and landing
Magazine: Flight Safety Digest
Volume: 22
Issue Number: 7-8
Date: July-August
Keywords: upset recovery training (URT), loss of control
Abstract: Loss of control was the category in which the most fatal accidents occurred during the 1993-2002 period. Approach-and-landing accidents were responsible for 10 of the year's 14 hull losses.
Notes: in issue Loss of Control: Returning from Beyond the Envelope
URL: http://flightsafety.org/fsd/fsd_jul-aug03.pdf

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Reference Type: Journal Article
Author: Folk, Charles L.; Remington, Roger W.
Year: 1994
Title: The structure of attentional control: Contingent attentional control by apparent motion, abrupt onset, and color
Journal: Journal of Experimental Psychology
Volume: 20
Pages: 317-329
Author's Title and Affiliation: NASA Ames Research Center
Keywords: spatial cueing, attentional capture, motion, abrupt onset, color
Abstract: Five spatial cueing experiments tested two hypotheses regarding attentional capture: (a) that attentional capture is contingent on endogenous attentional control settings and (b) that attentional control settings are limited to the distinction between dynamic and static discontinuities (Folk, Remington, & Johnston, 1992). In Experiments 1 and 2, apparent-motion precues produced significant costs in performance for targets signaled by motion, but not for targets signaled by color or abrupt onset. Experiment 3 established that this pattern is not due to differences in the difficulty of target discrimination. Experiments 4 and 5 revealed asymmetric capture effects between abrupt onset and apparent motion related to stimulus salience. The results support the hypotheses of Folk, et al. (1992) and suggest that stimulus salience may also play a role in attentional capture.

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Reference Type: Journal Article
Author: Ford, J. Kevin
Year: 2008
Title: Transfer of training: The criterion problem
Journal: Applied Psychology
Volume: 46
Issue: 4
Pages: 349-354
Date: Jan 22
Author's Title and Affiliation: J. Kevin Ford, Michigan State University
Abstract: There is a growing recognition of the "transfer problem" in organizational training as concerns are raised that much of what is trained fails to be applied in the work setting. This concern has become even stronger given today's changing job requirements and employment opportunities, the view of employees as the key to competitive advantage, and the movement towards continuous learning as a key mechanism for fully utilizing human resources.

Reference Type: Journal Article
Author: Förstberg, J.; Andersson, E.; Ledin, T.
Year: 1998
Title: Influence of different conditions for tilt compensation on symptoms of motion sickness in tilting trains
Journal: Brain Research Bulletin
Volume: 47
Issue: 5
Pages: 525-535
Author's Title and Affiliation: Swedish National Road and Transport Research Institute, Railway Systems, Linköping, Sweden
Royal Institute of Technology, Railway Technology, Stockholm, Sweden
Departments of ENT, University Hospital, Linköping, Sweden
Keywords: ride comfort, motion sickness, high-speed tilting trains
Abstract: Increased speeds of trains can be achieved by using tilting trains that decrease the lateral acceleration experienced by passengers on curves, thereby allowing trains to run typically 25-30% faster on existing curved track and maintaining good ride comfort. Unfortunately, motion sickness in tilting trains is a major problem for some passengers. To investigate the incidence of motion sickness and the extent to which different tilt compensation strategies influence its occurrence, tests were conducted with a tilting train on a track with a large number of curves. Eighty healthy volunteers were studied, selected partly for their susceptibility. Three different cars were evaluated during 3 test days, with each test ride lasting about 3 h. On four occasions per test ride, the subjects answered a questionnaire concerning activities during the ride, ride comfort, ability to work and read, vegetative symptoms, fatigue, sleepiness, nausea and well-being. Subjects' estimation of average ride comfort and ability to work and read was good in all conditions. However, 10% of the test subjects reported various symptoms of motion sickness (SMS). A 55% degree of tilt compensation of the lateral acceleration instead of the normal 70% reduced the symptoms of motion sickness incidence (SMSI) by 25-40%. SMSI correlated poorly with motion doses, which integrates vertical or lateral acceleration but correlated well with roll acceleration motion dose ($r2 = 0.43$, $p < 0.001$). For women, riding backward ($p < 0.001$) minimized SMSI, but men were insensitive to direction. Future railway design will have to optimize tilt systems by both minimizing motion sickness and avoiding excessive lateral acceleration or jerk.

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Reference Type: Workshop/Symposia
Author: Foster, Frank; Randle, Robert
Year of Workshop: 1983
Title: Simulation
Workshop Name: Flight Training Technology for Regional/Commuter Airline Operation
Workshop Location: Moffett Field, CA
Publisher: National Aeronautics and Space Administration (NASA), Ames Research Center
Date of Workshop: September 28-30
Author's Title and Affiliation: Foster: Ransome Airlines
Randle: National Aeronautics and Space Administration (NASA)
Abstract: (from first page) The simulation working group followed the discussion items in the symposium program, to wit: what simulation resources are available, what are the advantages, disadvantages, and shortcomings of simulators, how can simulators be used in cockpit resources management training (CRMT) by the small air carriers, and what research is needed to further develop simulation technology and the application of simulation in regional airline training programs? These are wide ranging topics and the group was hard-pressed to focus their discussion in view of the diversity of considerations that could and did arise. They ranged from all the problems with simulator specification, procurement, validation and use that have plagued the major air carriers over several decades to new problems related to the large diversity of aircraft, locale, and corporate size and operating style of the many regional airlines.

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Reference Type: Conference Paper
Author: Foster, John V.; Cunningham, Kevin; Fremaux, Charles M.; Shah, Gautam H.; Stewart, Eric C.; Rivers, Robert A.; Wilborn, James E.; Gato, William
Year: 2005
Title: Dynamics modeling and simulation of large transport airplanes in upset conditions
Conference Name: AIAA Guidance, Navigation, and Control Conference and Exhibit
Conference Location: San Francisco, CA
Publisher: American Institute of Aeronautics and Astronautics
Date: August 15-18
Electronic Resource Number: AIAA-2005-5933
Author's Title and Affiliation: John V. Foster, Kevin Cunningham, Charles M. Fremaux, Gautam H. Shah, Eric C. Stewart: NASA Langley Research Center, Hampton, VA
Robert A. Rivers: NASA Johnson Space Center, Houston, TX
James E. Wilborn, William Gato: The Boeing Company, Seattle, WA
Number of Pages: 13
Keywords: upset recovery training (URT)
Abstract: As part of NASA's Aviation Safety and Security Program, research has been in progress to develop aerodynamic modeling methods for simulations that accurately predict the flight dynamics characteristics of large transport airplanes in upset conditions. The motivation for this research stems from the recognition that simulation is a vital tool for addressing loss-of-control accidents, including applications to pilot training, accident reconstruction, and advanced control system analysis. The ultimate goal of this effort is to contribute to the reduction of the fatal accident rate due to loss-of-control. Research activities have involved accident analyses, wind tunnel testing, and piloted simulation. Results have shown that significant improvements in simulation fidelity for upset conditions, compared to current training simulations, can be achieved using state-of-the-art wind tunnel testing and aerodynamic modeling methods. This paper provides a summary of research completed to date and includes discussion on key technical results, lessons learned, and future research needs.

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Reference Type: Journal Article
Author: Frank, L. H.; Casali, J. G.; Wierwille, W. W.
Year: 1988
Title: Effects of visual display and motion system delays on operator performance and uneasiness in a driving simulator
Journal: Human Factors
Volume: 30
Issue: 2
Pages: 201-217

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Reference Type: Conference Paper
Author: Frank, Lawrence H.; Casali, John G.; Wierwille, Walter W.
Year: 1988
Title: Modeling operator control performance and well-being as a function of simulator visual and motion systems transport delays
Conference Name: Motion Cues in Flight Simulation and Simulator Induced Sickness
Conference Location: Brussels, Belgium
Publisher: Advisory Group for Aerospace Research and Development (AGARD)
Date: September 29
Author's Title and Affiliation: Frank: LCDR, MSC, USN, Ph.D., Head, Human Factors and Operational Analysis Branch, Pacific Missile Test Center, Point Mugu, CA 93042-5000
Casali: Ph.D., Virginia Polytechnic Institute and State University, Department of Industrial Engineering and Operations Research, Blacksburg, VA 24061

Wierwille: Ph.D., P.E., Virginia Polytechnic Institute and State University, Department of Industrial Engineering and Operations Research, Blacksburg, VA 24061
Keywords: visual and motion system transport delays, update frequency, control performance, simulator sickness, visual lead
Abstract: The role of visual-motion coupling delays and cueing order in operator performance and uneasiness was assessed in a driving simulator by means of a response surface methodology central-composite design. The most salient finding of the study was that visual delay appears to be more disruptive to an individuals control performance and well-being than is motion delay. Empirical multiple regression models were derived to predict 10 reliable measures of simulator operator driving performance and comfort. Principal components analysis of these 10 models decomposed the dependent measures into two significant models which were labeled vestibular disruption and degraded performance. Examination of the empirical models revealed that, for asynchronous delay conditions, better performance and well-being were achieved when visual system led the motion system. A secondary analysis of the tools of subject gender and perceptual style on susceptibility to simulator sickness revealed that neither of these independent variables was a significant source of variance.

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Reference Type: Electronic Article
Author: Frasca International
Year: 1997
Title: Frasca tells congress new flight training device may be unsafe
Volume: 2007
Issue: Feb. 5
URL: http://www.avweb.com/other/fras9746.html

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Reference Type: Magazine Article
Author: Frasca, Rudy
Year: 1998 (?)
Title: PCATDs counterpoint
Magazine: Airport Business
Date: March
Number of Pages: 3

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Reference Type: Workshop/Symposia
Author: Frasca, Rudolf A.
Year of Workshop: 1998
Title: PCATDs - A case for concern?
Workshop Name: RAeS Simulation Symposium
Workshop Location: London
Publisher: Frasca International, Inc.
Date of Workshop: May
Number of Pages: 19
Keywords: Personal Computer-Based Aviation Training Devices (PCATDs)
Abstract: The intent of this paper is to increase the level of awareness within the industry about the concern of a significant number of aviation training professionals regarding the FAA's Advisory Circular AC 61-126 Qualification and Approval of Personal Computer-Based Aviation Training Devices. This advisory circular allows hour-for-hour flight time credit up to ten hours for the use of PCATDs in the training of pilots for the Instrument Rating - Airplane. The author indicates the FAA's decision to implement the advisory circular was based on special interests and that the cited research in fact does not justify the allowance of flight time credit.

Reference Type: Report
Author: Fraser, T. M.
Year: 1966
Title: Human response to sustained acceleration
Type: Literature Review
Report Number: NASA SP-103
Author's Title and Affiliation: Lovelace Foundation for Medical Education and Research, Albuquerque, NM
Recipient's Title and Affiliation: National Aeronautics and Space Administration (NASA) Scientific and Technical Information Division, Washington, DC
Keywords: acceleration perception
Abstract: Outside of the problems associated with reduced barometric pressure, there is no field in the whole of aerospace bioscience that has received so much attention as that of acceleration. In consequence, a plethora of literature has arisen, good, bad, and indifferent, which by sheer volume almost defies analysis on the part of the most persistent reviewer. However, since much of the literature is repetitious or concerned with elucidation of the obvious, it is possible without too much sacrifice to obtain a tolerably clear picture of where we stand today in this field.
URL:
http://ntrs.nasa.gov/search.jsp?R=651614&id=1&qs=N%3D4294946780%26Ns%3DHarvestDate%7C1
Access Date: 6/17/08

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Reference Type: Report
Author: Freeman, J. S.; Watson, G.; Papelis, Y. E.; Lin, T. C.; Tayyab, A.; Romano, R. A.; Kuhl, J. G.
Year: 1995
Title: The Iowa driving simulator: An implementation and application overview
Institution: Society of Automotive Engineers (SAE)
Date: February
Type: SAE Technical Paper Series, No. 950174
Report Number: SAE Technical Paper Series, No. 950174
Author's Title and Affiliation: Center for Computer-Aided Design, 208 Engineering Research Facility, The University of Iowa, Iowa City, Iowa 52242-1000
Keywords: Iowa Driving Simulator (IDS)
Abstract: This paper presents an overview of the Iowa Driving Simulator (IDS), including its implementation and experimental applications. The Center for Computer–Aided Design (CCAD) at The University of Iowa began developing the IDS in 1990 with primary funding from the state of Iowa and the Advanced Research Projects Agency (ARPA). The simulator utilizes a recently developed real–time multibody dynamics formulation to create high fidelity, operator–in–the–loop vehicle simulations, a large six–degree–of–freedom hexapod motion base, wide field–of–view textured graphics with directional audio sources, and several interchangeable, instrumented cabs to provide realistic cueing feedback to the driver. Human factors issues currently being investigated by IDS researchers include experimental studies for the design and use of automated highway systems, usage of raised pavement markers for lane edge–line delineation, IVHS collision warning and roadway departure warning systems, advanced traveler information systems, performance assessment of challenged drivers, verification of driver performance in virtual environments, and more general issues of simulator fidelity and perceived realism. Two applications of the IDS are detailed: a study of Automated Highway Systems (AHS) and vehicle virtual prototyping on a virtual proving ground.

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Reference Type: Journal Article
Author: Fregly, A. R.; Graybiel, A.
Year: 1968
Title: Acute alcohol ataxia in persons with loss of labyrinthine function
Journal: Acta Oto-Laryngologica

Volume: 65
Issue: 5
Pages: 468-478
ISSN: 0001-6489 (Print)
Number of Pages: 11
Accession Number: 1970-06256-001
Keywords: oculogravic illusion perception, contact cues, synergistic vs antogonistic otolith-nonotolith information, labyrinthine defective men
Abstract: Investigated the effect of alcohol on the postural equilibrium of 7 persons with bilateral labyrinthine defects (LDs) to elucidate the functional role of the vestibular organ in man. The magnitude and duration of the intoxicating effects were less than observed previously in normal persons. The superimposition of an acute alcohol ataxia on Ss with pronounced, characteristic vestibular ataxia seemed to depend on the degree to which they were compensated for their loss of vestibular function. To the extent that experimental conditions were comparable for both normal and LD Ss the vestibular organ is regarded as contributing to acute alcohol ataxia.

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Reference Type: Journal Article
Author: Frigon, Jean-Yves; Delorme, Andre
Year: 1992
Title: Roll, pitch, longitudinal and yaw vection visually induced by optical flow in flight simulation conditions
Journal: Perceptual and Motor Skills
Volume: 74
Pages: 935-955
Author's Title and Affiliation: University of Montreal
Number of Pages: 21
Keywords: vection, perceived self-motion, visual field
Abstract: The present experiment was undertaken to study the effect of the addition of stimulation in the peripheral visual field on perceived self-motion (vection). The parameters were axes of motion, "Central + Peripheral" versus "Central" vision, frequencies of sinusoidal motion (0.2 Hz to 1.0Hz), and amplitudes. Vection generally increased with increased amplitudes and frequencies. In the "Central + Peripheral" condition, there was an interaction between frequencies and amplitudes. When stimuli were presented in "Central" vision only, vection was generally higher. It has been concluded that, for vection, the addition of visual stimulation in the periphery is more important at low sinusoidal frequencies and high amplitudes; at higher frequencies, this produces a decrease in vection probably attributable to an increase in object motion perception.

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Reference Type: Magazine Article
Author: Fritts, Dave
Year: 2002
Title: Advanced aviation weather products, now and in the future
Magazine: Air Line Pilot
Pages: 16
Date: May/June
Keywords: weather forecasting
Abstract: Airlines, flight and cabin crew members, and passengers are well aware of the effects of weather on air travel. Bad weather often results in delayed or canceled flights, missed connections or missing baggage, airport congestion, and unexpected overnight stays. Severe weather is occasionally implicated in in-flight injuries and airline accidents and incidents. Whereas passengers are usually only inconvenienced by weather, airlines measure weather-related losses in the billions of dollars. Garry Hinds, weather center operations manager for United Airlines in Chicago, says, "The large majority of irregular airline operations are weather-driven." Given the reality of weather risks, airlines and other

entities continue to explore how better weather information technology can improve weather knowledge and awareness and lessen the personal and corporate costs of weather in aviation.
URL: http://www.alpa.org/alpa/DesktopModules/ViewDocument.aspx?DocumentID=413

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Reference Type: Conference Proceedings
Author: Fuchs, Sven; Hale, Kelly S.; Stanney, Kay M.; Berka, Chris; Levendowski, Dan; Juhnke, Joseph
Year of Conference: 2007
Title: Physiological sensors cannot effectively drive system mitigation alone
Editor: Schmorrow, D.; Stanney, K.; Reeves, L.
Conference Name: Augmented Cognition: Past, Present, and Future
Publisher: Strategic Analysis, Inc.
Pages: 193-200
Number of Pages: 8
Abstract: While neurophysiological assessment can indicate a need for mitigation, this information alone reveals little with regard to what the right mitigation strategy would be for a given overload condition or how it should be configured (e.g. target modality or salience of a cue). To effectively incorporate mitigation strategies that optimize information displays for a given moment in time, cognitive state information alone is not sufficient; it must be assessed in context with other operator (e.g., eye gaze), task (e.g., current events, task accuracy), and environmental (e.g., time of day, weather) parameters. In this paper we present lessons learned from our AugCog effort and argue that real-time closed-loop AugCog systems can be significantly enhanced by integrating predictive theoretical models in order to provide an awareness of system, task, and environmental status that can drive mitigation selection and configuration.

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Reference Type: Conference Paper
Author: Furness III, T. A.
Year: 1986
Title: The super cockpit and its human factors challenges
Conference Name: Human Factors Society 30th Annual Meeting
Author's Title and Affiliation: Armstrong Aerospace Medical Research Laboratory, Wright-Patterson Air Force Base, Ohio 45433-6573
Number of Pages: 5
Keywords: super cockpit
Abstract: A revolutionary virtual crew station concept titled the "Super Cockpit" is introduced with its applications and operational advantages. Unique aspects of the virtual information portrayal and interactive medium of the super cockpit are discussed leading to a need for new areas of human factors research and engineering.
URL: http://www.hitl.washington.edu/publications/m-86-1/

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Reference Type: Magazine Article
Author: Gamauf, Mike
Year: 2006
Title: Down to the wire
Magazine: Business & Commercial Aviation
Volume: 98
Issue Number: 5
Pages: 82-85
Date: May
Keywords: Fly-by-wire (FBW), upset recovery training (URT)
Abstract: Fly-by-wire is coming to business aviation. Is your maintenance department ready?

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Reference Type: Journal Article
Author: Garrood, Stuart; Reid, Lloyd D.
Year: 1994
Title: Pilot evaluations of augmented flight simulator motion
Journal: Journal of Aircraft
Volume: 31
Issue: 4
Pages: 826-830
Date: July-August
Author's Title and Affiliation: Garrood: Graduate Student, University of Toronto Institute for Aerospace Studies, Toronto, Ontario M3H 5T6, Canada
Reid: Professor and Associate Director, Associate Fellow of AIAA, University of Toronto Institute for Aerospace Studies, Toronto, Ontario M3H 5T6, Canada
Number of Pages: 5
Keywords: flight simulator motion
Abstract: In an earlier paper it was proposed that the turbulence-induced motion of a flight simulator could be augmented without affecting the visual and instrument displays. This may be necessary if the simulator's washout filters severely restrict its motion response to atmospheric turbulence. The present study has implemented the proposed technique on the University of Toronto Institute for Aerospace Studies flight research simulator, and carried out pilot evaluations for both high-altitude and low-altitude operations in the presence of atmospheric turbulence in a manner that is acceptable to pilots. It was found that a simple second-order transfer function representation of the aircraft is sufficient within the motion augmentation channel. The resulting motions were judged to add to the realism of the simulation and to compare favorably with other training simulators.

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Reference Type: Report
Author: Gawron, Valerie J.
Year: 2002
Title: Airplane upset training evaluation report
City: Buffalo, NY
Institution: Veridian Engineering, National Aeronautics and Space Administration (NASA)
Pages: 1-536
Date: May
Report Number: NASA/CR 2002-211405
Author's Title and Affiliation: Veridian Engineering, Buffalo, NY
Number of Pages: 536
Keywords: upset recovery training (URT)
Abstract: Airplane upset accidents are a leading factor in hull losses and fatalities. This study compared five types of airplane-upset training. Each group was composed of eight, non-military pilots flying in their probationary year for airlines operating in the United States. The first group, "No aero/no upset," was

made up of pilots without any airplane upset training or aerobatic flight experience; the second group, "Aero/no upset," of pilots without any airplane-upset training but with aerobatic experience; the third group, "No aero/upset," of pilots who had received airplane-upset training in both ground school and in the simulator; the fourth group, "Aero/upset," received the same training as Group Three but in addition had aerobatic experience; and the fifth group, "In-Flight" received in-flight airplane upset training using an instrumented in-flight simulator. Recovery performance indicated that clearly training works--specifically, all 40 pilots recovered from the windshear upset. However few pilots were trained or understood the use of bank to change the direction of the lift vector to recover from nose high upsets. Further, very few thought of, or used differential thrust to recover from rudder or aileron induced roll upsets. In addition, recovery from icing-induced stalls was inadequate.

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Reference Type: Magazine Article
Author: Gawron, Valerie J.; Berman, Benjamin A.; Dismukes, R. Key; Peer, Jeffrey H.
Year: 2003
Title: New airline pilots may not receive sufficient training to cope with airplane upsets
Magazine: Flight Safety Digest
Volume: 22
Issue Number: 7-8
Date: July-August
Keywords: upset recovery training (URT)
Abstract: A study conducted for the U.S. National Aeronautics and Space Administration says that, although pilots cannot be trained for all imaginable scenarios, current airplane upset-recovery training might be expanded to include more types of upset conditions.
Notes: in issue Loss of Control: Returning from Beyond the Envelope
URL: http://flightsafety.org/fsd/fsd_jul-aug03.pdf

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Reference Type: Report
Author: Gebman, J. R.; Stanley, W. L.; Barbour, A. A.; Berg, R. T.; Birkler, J. L.; Chaloupka, M. G.; Goeller, B. F.; Jamison, L. M.; Kaplan, R. J.; Kirkwood, T. F.; Batten, C. L.
Year: 1986
Title: Assessing the benefits and costs of motion for C-17 flight simulators
Institution: Rand Corporation
Date: June
Report Number: R-3276-AF
Keywords: flight simulator, motion, cost analysis, training
Abstract: A framework for assessing the benefits and costs of incorporating a motion system in C-17 simulators is described. Three alternatives of C-17 simulator type are considered: a no-motion system, a system using combined hydraulic/pneumatic g-seats, and a system using a six-degree-of-freedom (dof) motion platform. The report shows that the motion platform alternative promises a large advantage over the other alternatives in terms of the range of tasks it can train, and also enjoys an advantage in terms of safety benefits, subjective considerations such as crew and instructor confidence, and its potential to reduce the risk of simulator sickness. It is estimated in the report that the incremental cost associated with the procurement and operation of the motion platform for 25 years is about 4% of the initial cost of the simulators. The study concludes that the cost of the motion platform simulator appears warranted when measured against potential improvements in flight safety and warfighting capability that result from the much greater training capability of the simulator.

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Reference Type: Report
Author: General Accounting Office (GAO)
Year: 1997
Title: Human factors: FAA's guidance and oversight of pilot crew resource management training can be improved
City: Washington, D.C.
Institution: General Accounting Office
Date: November
Report Number: GAO/RCED-98-7
Number of Pages: 23
Abstract: Previous studies of aviation safety have found that pilot performance is a major contributor to airline accidents and incidents (events that affect or could affect a flight's safety). Therefore, training to improve pilots' performance has been a primary effort to improve airline safety. As a part of this effort, some airlines have provided training in crew resource management (CRM) since the early 1980s, and the Federal aviation Administration (FAA) will require all airlines to have implemented this training for pilots by March 1998. CRM is an approach to improving pilot performance that focuses on better coordination--among members of the cockpit crew as well as among the cockpit crew and flight attendants, dispatchers, and air traffic controllers--to handle routine and emergency situations.
Airlines can meet the CRM training requirement in one of two ways: (1) by following FAA's traditional requirements for training pilots and crew--specified in part 121 of the federal aviation regulations--or (2) by instituting the Advanced Qualification Program (AQP), which combines CRM training with technical training for pilots. Part 121 training requirements have been in place without significant modification since the 1970s, and until 1990, all airlines had to meet these requirements. Since 1990, FAA has offered airlines AQP training as an alternative to traditional part 121 training, and eight major airlines have chosen to train their pilots under AQP requirements.
This report responds to your request that we examine the role of airline pilots' performance in accidents and FAA's efforts to address any inadequate performance. Specifically, we agreed to address the following:
(1) What are the types and frequency of accidents in which an airline pilots' performance was cited as a contributing factor, including those in which failure to use CRM principles was identified, and
(2) how adequate is FAA's guidance for and oversight of the airlines' implementation of pilots' training for CRM? We limited our review to the accidents and incidents experienced and training implemented by the 10 major U.S. airlines--those generating $1 billion or more in revenues annually.
URL: http://stinet.dtic.mil/cgi-bin/GetTRDoc?AD=ADA332641&Location=U2&doc=GetTRDoc.pdf

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Reference Type: Report
Author: General Accounting Office (GAO)
Year: 1999
Title: Aviation safety: Research supports limited use of personal computer aviation training devices for pilots
City: Washington, DC
Institution: United States General Accounting Office
Date: July 12
Report Number: GAO/RCED-99-143
Number of Pages: 46
Keywords: general aviation training, instrument training, personal computer-based aviation training device (PCATD)
Abstract: In 1998, general aviation had 1,907 accidents, with 621 fatalities. The National Transportation Safety Board estimates that 87 percent of all fatal general aviation accidents are caused by pilot error, especially when pilots who do not have appropriate instrument training fly when visibility is poor, such as during bad weather. To reduce the occurrence of general aviation accidents, the Federal Aviation Administration (FAA) has been exploring a number of means to enhance the training of general aviation pilots.

One possible enhancement is the use of new technologies for the training that occurs on the ground. For over 40 years, general aviation student pilots have used flight training devices to help them learn how to fly using an aircraft's instruments alone. These flight-training devices resemble an aircraft's cockpit and are often constructed with actual airplane instruments; they can be used by student pilots to substitute for up to 20 of the 40 hours of airplane training required by FAA to obtain an instrument rating. The instrument rating permits a pilot to fly when visibility is poor. In May 1997, FAA also approved the use of special personal computers, controls, and software called personal computer-based aviation training devices (PCATD), which can be used for up to 10 hours of instrument training. FAA's decision to allow the use of PCATDS has sparked debate. Some assert that pilots trained with these devices will be less skilled, thereby compromising aviation safety. Others argue that pilots trained with the devices are actually better trained at lower cost.
URL: http://stinet.dtic.mil/cgi-bin/GetTRDoc?AD=ADA366143&Location=U2&doc=GetTRDoc.pdf

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Reference Type: Magazine Article
Author: George, Fred
Year: 1999
Title: Upset recovery flight training
Magazine: Business & Commercial Aviation
Date: December
Keywords: upset recovery training (URT)
Abstract: Veridian Flight Research Group (a.k.a. Calspan) plans to broaden the scope of its professional services to include upset training for corporate pilots.

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Reference Type: Magazine Article
Author: George, Fred
Year: 2007
Title: Flying with Honeywell's synthetic vision system
Magazine: Aviation Week
Date: April 11
Abstract: [first paragraph] Synthetic Vision Systems are coming on strong for one simple reason. Anyone who has ever flown an Instrument Competency Check (ICC) ride under the hood of VFR conditions knows that "One peek is worth a thousand cross-checks." One quick look at the outside world instantly clears up any confusion regarding aircraft attitude, proximity to terrain and obstructions, and distance to go to the runway, among other critical elements of situational awareness.

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Reference Type: Magazine Article
Author: George, Fred
Year: 2008
Title: FAR Part 25 flight envelope protection, briefly
Magazine: Business & Commercial Aviation
Volume: 102
Issue Number: 2
Pages: 70-76
Date: February 1
Keywords: flight envelope protection, upset recovery training (URT)
Abstract: Understanding your aircraft's structural and aerodynamic limits can increase operating safety margins.

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Reference Type: Magazine Article
Author: George, Freg
Year: 2009
Title: RNP approach and departure procedures
Magazine: Aviation Week and Space Technology
Date: 02/01/2009
Number of Pages: 5

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Reference Type: Report
Author: George Mason University
Year: 1996
Title: Developing and evaluating CRM procedures for a regional air carrier: Phase I report
City: Washington, DC
Institution: Federal Aviation Administration (FAA), Office of the Chief Scientific and Technical Advisor for Human Factors
Date: May 30
Author's Title and Affiliation: George Mason University, 4400 University Drive, Fairfax, VA 22030-4444
Recipient's Title and Affiliation: Federal Aviation Administration, Office of the Chief Scientific and Technical Advisor for Human Factors, AAR-100, 800 Independence Avenue, S.W.
Keywords: crew resource management, CRM, advanced qualification program, AQP, line oriented evaluation, LOE, Atlantic Coast

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Reference Type: Report
Author: Gerathewohl, Siegfried J.
Year: 1969
Title: Fidelity of simulation and transfer of training: A review of the problem
City: Furstenfeldbruck, Germany
Institution: Institute of Aviation Medicine
Date: Dec.
Author's Title and Affiliation: Siegfried J. Gerathewohl, Ph.D.
Number of Pages: 20
Keywords: bibliographies, educational specifications, equipment evaluation, flight training, realism, research, simulated environment, simulation, transfer of training
Abstract: The document is concerned with the several kinds of flight simulators available today which are valuable tools for research, training, and proficiency measurement. They range from simple trainer type devices useful for learning specific tasks, to very sophisticated ground based facilities and aircraft used for crew training under simulated environmental and operational conditions. The various perceptual phenomena and performance modes observed indicate that it is not physical similarity of devices, but psychological, physiological, and operational realism, which determines realism in simulation. In general, the amount of transfer of training seems closely related to the degree of fidelity which can be provided. (Ten figures and 28 references are included.) (Author/LY)
URL: http://www.faa.gov/library/reports/medical/oamtechreports/1960s/media/AM69-24.pdf
Access Date: 06/01/2010

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Reference Type: Report
Author: Gertner, Izidor C.; Wolberg, George; Geri, George A.; Kelly, George R.; Pierce, Byron J.; Thomas, Melvin; Martin, Elizabeth L.
Year: 1994
Title: A PC-based photographic-quality image generator for flight simulation
Author's Title and Affiliation: Gertner, Wolberg: City College of New York (CUNY), Department of Computer Science, New York, NY 10031

Geri, Kelly: University of Dayton, Research Institute, Higley, AZ 85236-2020
Pierce, Thomas, Martin: Air Force, Armstrong Laboratory, Mesa, AZ 85206
Number of Pages: 7
Keywords: PC-based, photographic-quality image generator, flight simulation, multiple instruction multiple data, MIMD, rendering, Gouraud shading, incremental texture mapping, filtering

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Reference Type: Journal Article
Author: Gianna, Claire; Heimbrand, S.; Gresty, M.
Year: 1996
Title: Thresholds for detection of motion direction during passive lateral whole-body acceleration in normal subjects and patients with bilateral loss of labyrinthine function
Journal: Brain Research Bulletin
Volume: 40
Issue: 5-6
Pages: 443-449
Electronic Resource Number: 10.1016/0361-9230(96)00140-2
Number of Pages: 7
Accession Number: 1997-07950-020
Keywords: Perception, Linear, Dtolith, Vestibular, Somatosensory.
Abstract: To investigate the effect of velocity, acceleration, and gradient of acceleration on self-motion perception, thresholds for detection of direction of whole-body interaural acceleration were determined for various stimulus profiles. For acceleration steps, acceleration thresholds at 67% correct detection of motion direction were similar for eight normals (mean 4.64 cm/s2 (range 2.9-6.3), peak gradient = 22 cm/s and five labyrinthine-defective subjects (mean 5.65 cm/s2 (4.65-6.6), peak gradient = 25 cm/s2). Velocity thresholds were 7.93 cm/s for a proportion of correct responses of 73% for normals and 9.67 cm/s for 69% of correct detection for avestibular subjects. For linear and parabolic accelerations, high intersubject variability was observed both among nine normals and three labyrinthine-defective subjects. Mean normal and avestibular subjects' acceleration thresholds for 74% of correct responses were respectively 12.1 cm/s2 (7.3-20.4) and 16.4 cm/s2 (13.2-20) for a ramp with gradient of acceleration = 2.6 cm/s3, 19.2 cm/s2 (10.4-35.3) and 26.2 cm/s2 (21.4-32.6) for a ramp with gradient= 7.9 cm/s3 and 16.7 cm/s' (10.5-25) and 20.6 cm/s* 116.4-
24.2) for a parabola with seconb derivative = 1.52 cm/s2. The
corresponding velocity thresholds for normals were 21.2 cm/s (5.2-50.3), 22.0 cm/s (7-56.6), and 22.2 cm/s (9.6-43.7). The lowest thresholds were obtained for acceleration steps indicating that a high acceleration gradient facilitates motion perception. For linear and parabolic accelerations, motion perception seemed to follow an integration of acceleration, but a high intersubject variability was observed. For all stimuli, the range of thresholds for normals and avestibular subjects overlapped showing that detection of motion was not a sole prerogative of the otoliths but could also be performed using somatosensory cues.

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Reference Type: Conference Paper
Author: Gilbert, William P.; Nguyen, Luat T.
Year: 1978
Title: Use of piloted simulation for studies of fighter departure/spin susceptibility
Conference Name: Flight Mechanics Panel Specialists' Meeting on Piloted Aircraft Environment Simulation Techniques
Conference Location: Brussels, Belgium
Publisher: Advisory Group for Aerospace Research and Development (AGARD)
Date: April 24-27
Author's Title and Affiliation: Aeronautical Engineers, NASA Langley Research Center, Mail Stop 355, Hampton, VA 23665
Number of Pages: 13

Keywords: departure/spin susceptibility, stall
Abstract: The NASA-Langley Research Center has incorporated into its stall-spin research program on military airplanes the use of piloted, fixed-base simulation to complement the existing matrix of unique research testing techniques. The piloted simulations of fighter stall/departure flight dynamics are conducted at the Langley Differential Maneuvering Simulator (DMS). This paper reviews the objectives of the simulation research, presents the rationale underlying the simulation methods and procedures used in the evaluation of airplane characteristics, and discusses in detail the evaluation steps used to assess fighter stall/departure characteristics. Simulation results are presented to illustrate the flight dynamics phenomena dealt with.
The considerable experience accumulated in the conduct of piloted stall/departure simulation indicates that simulation provides a realistic evaluation of an airplane's maneuverability at high angles of attack and an assessment of the departure and spin susceptibility of the airplane. This realism is obtained by providing the pilot a complete simulation of the airplane and control system which can be flown using a realistic cockpit and visual display in simulations of demanding air combat maneuvering tasks. The use of the piloted simulation methods and procedures described in the paper have been found very effective in identifying stability and control problem areas and in developing automatic control concepts to alleviate many of these problems. A good level of correlation between simulated flight dynamics and flight test results has been obtained over many fighter configurations studied in the simulator.

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Reference Type: Report
Author: Gillingham, K.; Previc, Fred
Year: 1993
Title: Spatial orientation in flight
Institution: Armstrong Laboratory, Crew Systems Directorate, Crew Technology Division
Date: November
Report Number: AL-TR-1993-0022
Author's Title and Affiliation: Crew Systems Directorate, Crew Technology Division, 2504 D Drive, Suit 1, Brooks Air Force Base, TX 78235-5104
Recipient's Title and Affiliation: Armstrong Laboratory, Crew Systems Directorate, Crew Technology Division, 2504 D Drive, Suite 1, Brooks Air Force Base, TX 78235-5104
Keywords: upset recovery training (URT), motion sickness, pilot vertigo, spatial disorientation, spatial orientation, vestibular function, visual orientation
Abstract: Human spatial orientational mechanisms, and how those mechanisms fail in flight, are discussed in detail in this comprehensive review. Specific topics include: mechanics and associated physiologic nomenclature; visual orientation; vestibular function and information processing; other orientational senses; spatial disorientation, including definitions, types, causes, examples, statistics, and methods of preventing spatial disorientation mishaps; and the significance, etiology, and therapy of motion sickness. Forty-four figures are included, many illustrating vestibular anatomy physiology, and others depicting the more common visual and vestibular illusions in flight.
URL: http://stinet.dtic.mil/oai/oai?&verb=getRecord&metadataPrefix=html&identifier=ADA279306

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Reference Type: Journal Article
Author: Gillingham, Kent K.
Year: 1992
Title: The spatial disorientation problem in the United States Air Force
Journal: Journal of Vestibular Research
Volume: 2
Pages: 297-306
Date: August 4
Author's Title and Affiliation: MD, PhD; Flight Motion Effects Branch, Crew Technology Division, Crew Systems Directorate, Armstrong Laboratory, Brooks Air Force Base, Texas

Keywords: spatial disorientation, disorientation, spatial orientation, pilot vertigo, upset recovery training (URT)
Abstract: Spatial disorientation (SD) in flight wastes hundreds of millions of dollars worth of defense capability annually and continues to kill aircrew. SD results primarily from inadequacies of human visual and vestibular sensory systems in the flying environment; but other factors, such as task saturation and distraction, precipitate it. The United States Air Force is conducting a three-pronged research and development effort to solve the SD problem. We are attempting 1) to elucidate further the mechanisms of visual and vestibular orientation and disorientation, 2) to develop ground-based and inflight training methods for demonstrating to pilots the potential for SD and the means of coping with it, and 3) to conceive and evaluate new ways to display flight control and performance information so that pilots can maintain accurate spatial orientation.
Author Address: Kent K. Gillingham, MD, PhD, AL/CFTF, Brooks Air Force Base, TX 78235-5000

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Reference Type: Report
Author: Gilliom, David C.; Spears, William D.; Demuth, H. Jan; Eddy, Paul P.; Hanley, David E.; Holmbeck, Glenn E.; Fishburne, Robert P.
Year: 1985
Title: A systematic determination of skill and simulator requirements for airline transport pilot certification
City: Washington, DC
Institution: Office of Flight Operations
Date: March
Report Number: DOT-TSC-FAA-85-1
Author's Title and Affiliation: Planning Systems International, Inc., 200 Little Falls Street, Suite 104, Falls Church, VA 22406
Number of Pages: 254
Keywords: simulation requirements, pilot performance, cue analysis, skill analysis, visual simulation, motion simulation, aircraft systems simulation, pilot certification, FAA airman certification system
Abstract: This research report describes:
(1) the FAA's ATP airman certification system;
(2) needs of the system regarding simulator use;
(3) a systematic methodology for meeting these needs;
(4) application of the methodology;
(5) results of the study; and
(6) conclusions.
The methodology developed is Airman Certification Systems Development, or ACSD. Application of ACSD entailed a systematic study of the airman certification process. The study produced behaviorally defined evaluation and training objectives; sensory cue and behavioral analyses to support these objectives; and a statement of media requirements based on the objectives and behavioral and cueing data. This report provides comprehensive documentation of the results of the ACSD methodology as a tool to analyze simulator use in FAA airline transport pilot certification.

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Reference Type: Web Page
Author: Gilmore, Tom
Year: 2001
Title: Flying right seat on a PCATD
Series Editor: Flightgear
Access Year: 2007
Access Date: Feb. 5
Type of Medium: Online article
URL: http://fgatd.sourceforge.net/nafi-PCATD.html

Reference Type: Conference Proceedings
Author: Gingras, David R.; Ralston, John N.
Year of Conference: 2008
Title: Aerodynamics modeling for upset training
Conference Name: AIAA Modeling and Simulation Technologies Conference
Conference Location: Honolulu, HI
Publisher: American Institute of Aeronautics and Astronautics (AIAA)
Date: August 18-21
Electronic Resource Number: AIAA 2008-6870
Author's Title and Affiliation: Bihrle Applied Research Inc., Hampton, VA
Number of Pages: 16
Keywords: aerodynamics modeling, upset recovery training (URT)
Abstract: Airplane upset and Loss of Control (LOC) is a leading cause of accidents in commercial and general aviation operations. A number of measures have been taken in the commercial segment to improve training and awareness of this problem and several organizations offer in-flight training to enhance awareness. In relative terms, in both commercial and general aviation sectors, the use of Full Flight Simulators (FFS) and Flight Training Devices (FTD) for this purpose, is minimal. A key reason for this is the limited capability and coverage of flight models used in these devices. This paper provides examples of the limitations in civilian simulators in contrast to military efforts that have been using full envelope modeling for decades to enhance pilot training. The paper also presents techniques used in full-envelope modeling, their validity, and how these approaches should be applied to civilian trainer development.

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Reference Type: Journal Article
Author: Glasauer, S.; Amorim, M.-A.; Vitte, E.; Berthoz, A.
Year: 1994
Title: Goal-directed linear locomotion in normal and labyrinthine-defective subjects
Journal: Experimental Brain Research
Volume: 98
Issue: 2
Pages: 323-335
Number of Pages: 13
Keywords: path integration, locomotion, vestibular system, vestibular disorders, human
Abstract: When a subject is walking blindfolded straight ahead towards a previously seen target, the brain must update an internal representation with respect to the environment. This study examines whether the information given by the vestibular system is necessary for this simple path integration task and gives a quantitative description of locomotor behaviour during the walk by comparing ten normal and seven bilateral labyrinthine-defective (LD) subjects. Each subject performed 20 blindfolded walks (EC) and ten walks with eyes open (EO) towards a target attached to the floor 4 m in front of them; these walks were made at different velocities. The positions of head, trunk and feet were recorded using a 3D motion analysis system. No significant difference was found between normal and LD groups in terms of the distance error of reaching the target, while LD subjects showed a larger lateral error. Path curvature, expressed as the standard deviation of the angle between the direction of one step and straight ahead, was found to be significantly larger for LD subjects in the EC condition, demonstrating their instability when walking without vision. Mean walking velocity was lower for LD subjects than for normal subjects in both EC and EO conditions. Both groups walked faster with eyes open; LD subjects increased their velocity by increasing step length, normal subjects by increasing step frequency. Head stabilization in the frontal plane during locomotion was not significantly different between LD and normal subjects, whereas both head and trunk rotation were slightly larger in LD subjects during blindfolded walking. The results show that bilateral LD subjects are able to perform linear goal-directed locomotion towards memorized targets. Thus, the vestibular system does not appear to be necessary for active linear path integration.

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Reference Type: Web Page
Author: Gleim Publications, Inc.
Year: 2006
Title: Advanced pilot training
Publisher: Gleim
Access Year: 2006
Access Date: Sept 6.
Number of Pages: 12
Keywords: instrument rating, commercial pilot certificate, flight instructor certificate, ground instructor certificate, airline transport pilot certificate
Notes: As of Sept. 6, 2006 the original web page was no longer available, but other pilot training programs, books, etc. are described at http://www.gleim.com/aviation/pilot.php.
URL: http:\\www.gleim.com/Aviation/AdvancedTraining.html

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Reference Type: Conference Paper
Author: Go, T. H. ; Bürki-Cohen, J.; Chung, W. W.; Schroeder, J.; Saillant, G.; Jacobs, S.; Longridge, T.
Year: 2003
Title: The effects of enhanced hexapod motion on airline pilot recurrent training and evaluation
Conference Name: AIAA Modeling and Simulation Technologies Conference
Conference Location: Austin, TX
Publisher: American Institute of Aeronautics and Astronautics (AIAA)
Electronic Resource Number: AIAA-2003-5678
Author's Title and Affiliation: Go: Aerospace Research Engineer, Massachusetts Institute of Technology (MIT), Cambridge, MA
Bürki-Cohen: P.I., Flight Deck Human Factors Program, U.S. Department of Transportation/Volpe National Transportation Systems Center, Cambridge, MA
Chung: Aerospace Engineer, SAIC, Lexington Park, MD
Schroeder: Deputy Branch Chief, NASA Ames Research Center, Moffett Field, CA
Saillant: Senior Software Engineer, Northrop Grumman Information Technology, Moffett Field, CA
Jacobs: Engineering Psychology Student Fellow, U.S. Department of Transportation/Volpe National Transportation Systems Center, Cambridge, MA
Longridge: Manager, Voluntary Safety Programs Branch, AFS-230, Federal Aviation Administration, Washington, DC
Abstract: A quasi-transfer experiment tested the effect of simulator motion on recurrent evaluation and training of airline pilots. Two groups of twenty B747-400 pilots were randomly assigned to a flight simulator with or without platform motion. In three phases, they flew four maneuvers designed to reveal differences due to motion. In the first phase, termed Evaluation, the two groups flew the maneuvers as they would in a check ride. In the second phase, termed Training, the two groups flew the maneuvers repetitively and were given feedback on their performance. In the third phase, termed Quasi-Transfer, both groups flew the tasks again, but both in the simulator with motion (quasi-transfer instead of real transfer to the airplane). This was to determine whether or not their previous training with or without motion made any difference. Statistically significant effects of both motion and the phase of experiment were found for all four maneuvers. Platform motion was shown to make a difference in Evaluation, but was not found to be of benefit in Training. Results of this study and the previous hexapod motion research should assist the FAA in determining future research directions in the effort to develop motion requirements for today's airline evaluation and training needs.
URL: http://www.volpe.dot.gov/hf/docs/aiaa03.pdf

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Reference Type: Conference Paper
Author: Go, T.H.; Bürki-Cohen, J.; Soja, N.N.
Year: 2000
Title: The effect of simulator motion on pilot vehicle training and evaluation

Conference Name: AIAA Modeling and Simulation Technologies Conference
Conference Location: Denver, CO
Publisher: American Institute of Aeronautics and Astronautics (AIAA)
Date: August 14-17
Electronic Resource Number: AIAA-2000-4296
Author's Title and Affiliation: Tiauw H. Go: Postdoctoral Associate, Department of Aeronautics and Astronautics, Massachusetts Institute of Technology, Cambridge, MA
Judith Bürki-Cohen: Engineering Psychologist, Volpe Center, U.S. Department of Transportation, Cambridge, MA
Nancy N. Soja: Consultant, experimental psychology, Brookline, MA
Number of Pages: 10
Abstract: This study empirically examined the effect of simulator platform motion on airline pilot recurrent training and evaluation. It is driven by the need for sound scientific data on the relationship between certain key modern device features and their effect on the transfer of pilot performance and behavior to and from the respective airplane. The experiment utilized an FAA qualified Level C simulator with six-degree-of-freedom synergistic motion and a wide angle high quality visual system. Experienced airline pilots were evaluated and trained in the simulator, half of them with and the other half without motion. Then the transfer of skills acquired by both groups during this training was tested in the simulator with the motion system turned on as a stand-in for the airplane (quasi-transfer). Every effort was made to avoid deficiencies in the research design identified in a review of prior studies, by measuring pilot simulation *and* response, testing both maneuvers and pilots that are *diagnostic* of a need of motion, avoiding pilot and instructor *bias*, and ensuring sufficient statistical *power* to capture operationally relevant effects. The results of the analyses as well as their implications are presented in this paper.
URL: http://www.volpe.dot.gov/hf/docs/aiaadoc.pdf

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Reference Type: Journal Article
Author: Go, T. H.; Ramnath, R. V.
Year: 2002
Title: Analysis of the two-degree-of-freedom wing rock in advanced aircraft
Journal: Journal of Guidance, Control, and Dynamics
Volume: 25
Issue: 2
Pages: 324-333
Date: March-April
Author's Title and Affiliation: Massachusetts Institute of Technology, Cambridge, MA 02139
Number of Pages: 10
Abstract: The dynamics of wing rock on rigid aircraft having two rotational degrees of freedom are analyzed. Nonlinear mathematical models of the aircraft are developed for the purpose of the analysis. The aerodynamic expressions contained in the models are built by putting the appropriate aerodynamic data into the model. The nonlinear dynamics are analyzed using a technique combining the multiple time scales method, center manifold reduction principle, and bifurcation theory. Analytical solutions are developed in parametric forms showing a separation of the fast and slow dynamics. Such solutions have an advantage over numerical solutions in that the important parameters and their effects on wing rock characteristics, such as amplitude and frequency, are easily seen in explicit functional relationships. An excellent agreement between the analytical results and the numerical simulations is demonstrated.

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Reference Type: Journal Article
Author: Gore, Brian F.
Year: 2002
Title: Human performance cognitive-behavioral modeling: A benefit for occupational safety
Journal: International Journal of Occupational Safety and Ergonomics
Volume: 8

Issue: 3
Pages: 339-351
Number of Pages: 13
Keywords: modeling system safety, human performance modeling, human factors methodology, human-out-of-the-loop (HOOTL) simulations
Abstract: Human Performance Modeling (HPM) is a computer-aided job analysis software methodology used to generate predictions of complex human-automation integration and system flow patterns with the goal of improving operator and system safety. The use of HPM tools has recently been increasing due to reductions in computational cost, augmentations in the tools' fidelity, and usefulness in the generated output. An examination of an Air Man-machine Integration Design and Analysis System (Air MIDAS) model evaluating complex human-automation integration currently underway at NASA Ames Research Center will highlight the importance to occupational safety of considering both cognitive and physical aspects of performance when researching human error.

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Reference Type: Journal Article
Author: Goteman, Orjan; Dekker, Sidney
Year: 2006
Title: Flight crew callouts and aircraft automation modes
Journal: International Journal of Applied Aviation Studies
Volume: 6
Issue: 2
Pages: 235-248
Number of Pages: 15
Abstract: New aircraft come with a set of recommended standard operating procedures, in the case of multi-crew aircraft this includes "callouts"—verbalizations of particular flight guidance automation mode changes. In an attempt to reduce the risk for mode confusion some operators have required flight crews to callout all flight guidance automation mode changes as a means of forcing pilots to monitor the Flight Mode Annunciator (FMA). Previous research has shown that crews do not spend enough time on the flight mode annunciator, and skip mode call-outs as well as making call-outs in advance of annunciations; there has been no report of any system or regularity in the shedding and adaptation of callouts. One reason could be the contrived empirical simulator settings of such research, which we aimed to augment with natural observations of real cockpit work reported here. With the hope of answering, in more detail, how required verbal coordination of annunciated mode changes gets adapted to real settings we observed 19 line flights with three different airlines from the first observer's seat in the cockpit. We found that many callouts were simply shed in high-workload situations, and found regularity in the kind of callouts being shed. Callouts relating to aircraft automation, such as FMA call-outs, were shed before other required callouts. Our results suggested that FMA callouts were not used as a tool to detect or remember automation mode changes but as a vehicle for coordinating between the pilots themselves, a finding that could serve as a reminder for future design of callout procedures.

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Reference Type: Book Section
Author: Gotoh, T.
Year: 1982
Title: Can the acoustic head-related transfer function explain every phenomenon in sound localization?
Editor: Gatehouse, R. W.
Book Title: Localization of Sound: Theory and Applications
City: Groton, CT
Publisher: Amphora Press
Pages: 244-248
Author's Title and Affiliation: Acoustic Research Laboratory, Matsushita Electric Industrial Company, Limited, Osaka, Japan
Number of Pages: 5

Reference Type: Report
Author: Government Accountability Office (GAO)
Year: 2007
Title: Very light jets: Several factors could influence their effect on the National Airspace System
Institution: United States Government Accountability Office
Pages: 1-43
Date: August
Report Number: GAO-07-1001
Recipient's Title and Affiliation: Congress
Abstract: For several years, a number of aviation manufacturers have been designing and testing very light jets, a type of small jet aircraft equipped with advanced technologies and priced below other business jets. Aviation forecasters predict that thousands of very light jets will enter the National Airspace System (NAS) over the next two decades, contributing to the overall growth of the general aviation fleet. While some experts predict that very light jets will be used in ways that are similar to current general aviation aircraft, others predict that they will be used to expand the air taxi market to provide on-demand, point-to-point air transportation. In 2006, the Federal Aviation Administration (FAA) certified the first very light jets for flight. This report identifies (1) current very light jet forecasts and what factors could affect very light jet deliveries, (2) how increasing numbers of very light jets might affect the capacity and safety of the NAS, (3) how FAA is planning to accommodate the entry of very light jets into the NAS, and (4) how very light jets might affect FAA's costs and Airport and Airway Trust Fund revenues. To address these issues, GAO reviewed relevant documents and interviewed agency officials and aviation experts.
URL: http://www.gao.gov/new.items/d071001.pdf

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Reference Type: Conference Paper
Author: Gower, Daniel W.; Kennedy, Robert S.; Lilienthal, Michael G.; Fowlkes, Jennifer E.
Year: 1987
Title: Simulator sickness in U.S. Army and Navy fixed- and rotary-wing flight simulators
Conference Name: Aerospace Medical Panel Symposium on Motion Cues in Flight Simulation and Simulator Induced Sickness
Conference Location: Brussels, Belgium
Publisher: Advisory Group for Aerospace Research and Development (AGARD)
Date: September 29
Author's Title and Affiliation: Gower: MAJ, Director, Biodynamics Research Division, U.S. Army Aeromedical Research Laboratory, P.O. Box 577, Fort Rucker, AL 36362-5292
Kennedy: Ph.D., Facility Director, Essex Corporation, 1040 Woodcock Road, Orlando, FL 32803
Lilienthal: LCDR, Branch Head, Training & Development Branch, Human Factors Division, Naval Training Systems Center, Orlando, FL 32813-7100
Fowlkes: Ph.D., Staff Scientist, Essex Corporation, 1040 Woodcock Road, Orlando, FL 32803
Number of Pages: 20
Keywords: simulator sickness, fixed wing, rotary wing, motion, visual
Abstract: As technology has been developed to provide improved visual and motion systems in operational flight trainers and weapon tactics trainers there have been increasing reports of the occurrence of simulator sickness. Simulator sickness here refers to one or more symptoms which can occur while in a simulator, immediately postexposure, or at some time later following exposure. Flight instructors have complained that these symptoms interfere with simulator usage. Some pilots have reports when driving following postexposure, they have had to pull off the road and wait for symptoms to subside. Instructor-operators have reported experiencing "the room spinning" when they went to bed. More critical is the potential for inflight problems due to prolonged physiological effects. As a result, flight activities after simulator flight have been limited by some commands.
The U.S. Army Aeromedical Research Laboratory at Fort Rucker, Alabama and the Naval Training Systems Center at Orlando, Florida have conducted field surveys to document the extent of the simulator sickness problems at operational fixed- and rotary-wing simulator sites. Data are pooled from 10 different Navy flight simulators and the Army's AH-64 flight simulator. The total number of surveys is approximately 1500, with the number of subjects in each simulator type ranging from 28 to 280. The simulator sickness

incidence rates and the relative frequency of specific symptoms are presented and correlation factors such as flight experience, simulator experience, and flight mode are also represented. Difficulties in assessing the duration of simulator sickness effects are noted, and attempts are made to present the symptom duration for the Army's AH-64 combat mission simulator (CMS). Unique to this CMS is its use of the helmet display unit (HDU) in conjunction with other visuals in the simulator.
The combined Army and Navy simulator sickness database is an ongoing attempt to relate symptoms to specific equipment features, simulator instructional techniques, training procedures, and trainee characteristics. The study reinforces the need for continued research related to system design, training methods, and crew rest guidelines between simulator and actual flight.
URL: http://stinet.dtic.mil/oai/oai?verb=getRecord&metadataPrefix=html&identifier=ADA202492

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Reference Type: Conference Paper
Author: Gran, Lars; Gimmestad, Jarle
Year: 2003
Title: Training potential of ATC simulation in FFS-pilot training
Conference Name: Simulation of the Environment Conference
Conference Location: London, UK
Publisher: Royal Aeronautical Society (RAeS)
Number of Pages: 4
Abstract: Current accident statistics indicate that the pilot/ATC Controller interface is a contributing factor in airline accidents, incidents and episodes. This may be caused by complicated or ambiguous clearances, unfamiliar procedures, or simply mishearing or misunderstanding.
These data are confirmed by LOA finding from numerous airlines all over the world.
We will conclude that training in simulators with enhanced ATC environments will greatly amend today's pilot training.

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Reference Type: Conference Proceedings
Author: Grant, Peter R.; Advani, Sunjoo K.; Liu, Yang; Haycock, Bruce
Year of Conference: 2007
Title: An iterative learning control algorithm for simulator motion system control
Conference Name: AIAA Modeling and Simulation Technologies Conference and Exhibit
Conference Location: Hilton Head, SC
Publisher: American Institute of Aeronautics and Astronautics (AIAA)
Date: August 20-23
Electronic Resource Number: AIAA 2007-6471
Author's Title and Affiliation: Grant: Assistant Professor, Institute for Aerospace Studies, University of Toronto, Toronto, Ontario, Canada
Advani: President, IDT, Breda, The Netherlands
Liu: Undergraduate Student, Engineering Science, University of Toronto, Toronto, Ontario, Canada
Haycock: Research Engineer, Institute for Aerospace Studies, University of Toronto, Ontario, Canada
Abstract: In flight simulation, closed-loop motion cueing provides feedback to the pilot based on continuous control inputs. In some cases however, disturbances based on external triggers are also necessary. For example, taxiing over runway bumps, engine-related vibrations, and specific system failures cause awareness cues that are less dependent on the instantaneous control inputs by the pilot. These are motions that are triggered by specific events. Realizing the frequency content of these events in a temporally accurate way can be difficult, especially with limited motion platform dynamics. In addition, research simulators are often used for human perception experiments, where humans are subject to predefined waveforms. These waveforms are often significantly distorted by the dynamic response of the simulator's motion system. An iterative learning controller was developed to improve the motion of a flight simulator in these situations. The controller was shown to significantly improve the response of the simulator to a jerk-limited acceleration square wave. Seven to ten iterations were required to converge to an acceptable response depending on the exact configuration of the controller. Rather than using a potentially destabilizing increase in feedback gain, the controller distorts the commands to achieve the

desired response. The distorted commands can then be stored and later called upon to generate the desired motions as a function of a triggered input signal.
Author Address: Grant and Haycock: Institute for Aerospace Studies, University of Toronto, 4925 Dufferin St., Toronto, Ontario, M3H 5T6, Canada
Advani: Overkroetenlaan 162, 4823 KB Breda, The Netherlands

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Reference Type: Journal Article
Author: Grant, Peter R.; Reid, Lloyd D.
Year: 1995
Title: Motion washout filter tuning: Rules and requirements
Journal: Journal of Aircraft
Volume: 34
Issue: 2
Pages: 145-151
Date: March-April
Author's Title and Affiliation: University of Toronto
Number of Pages: 7
Abstract: Current motion-drive algorithms have a number of coefficients that are selected to tune the motion of the simulator. Little attention has been given to the process of selecting the most appropriate coefficient values. Final tuning is best accomplished using experienced evaluation pilots to provide feedback to a washout filter expert who adjusts the coefficients in an attempt to satisfy the pilot. This paper presents the development of a tuning paradigm and the capturing of such within an expert system. The focus of this development is the University of Toronto classical algorithm, but the results are relevant to alternative classical and similarly structured adaptive algorithms. This paper provides the groundwork required to develop the tuning paradigm. The necessity of this subjective tuning process is defended. Motion cueing error sources within the classical algorithm are revealed, and coefficient adjustments that reduce the errors are presented.

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Reference Type: Journal Article
Author: Grant, Peter R.; Tung Sing Lee, Peter
Year: 2007
Title: Motion-visual phase-error detection in a flight simulator
Journal: Journal of Aircraft
Volume: 44
Issue: 3
Pages: 927-935
Date: May-June
Author's Title and Affiliation: Grant: Assistant Professor, Institute for Aerospace Studies, University of Toronto
Tung Sing Lee: Engineer I, Honeywell Aerospace
Abstract: An experiment was conducted on the University of Toronto Institute for Aerospace Studies Flight Research Simulator to determine the minimum phase lead of pitch motion cues relative to pitch visual cues that can be consistently detected by a human observer. The effects of pitch frequency and amplitude, motion gain, and visual scene complexity on the detection threshold of the phase error between the visual and motion cues was determined. The mean detection threshold of the phase error averaged across all subjects and conditions was 57 deg. Pitch amplitude significantly affected the detection threshold of phase error. Higher amplitudes led to lower detection thresholds. Motion gain also had a significant effect on the detection threshold of the phase error when the frequency was 0.2 Hz and the visual complexity was low. Higher motion gains led to lower detection thresholds. The frequency had a significant effect on the detection threshold of the phase error when motion gain was 0.5 or the visual complexity was low. Higher frequencies led to lower detection thresholds. The direction of the frequency effect suggests that subjects perform more like motion-visual detectors than motion-visual time delay

detectors. The results of the experiment were used to analyze pitch high-pass washout filters. The analysis suggests that the break frequency for a second-order washout filter should be lower than 0.13 rad/s and the break frequency for a first-order filter should be lower than 0.2 rad/s to keep the motion-visual phase error below the measured human perception limit.
Notes: Presented as Paper 5892 at AIAA Modeling and Simulation Technologies Conference, San Fransisco, CA, August 15-18, 2005
Author Address: Grant: University of Toronto, Institute for Aerospace Studies, 4925 Dufferin Street, Toronto, Ontario M3H 5T6, Canada
Tung Sing Lee: Honeywell Aerospace, 3333 Unity Drive, Mississauga, Ontario L5L 3S6, Canada

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Reference Type: Journal Article
Author: Grant, Peter R.; Yam, Bonnie; Hosman, Ruud; Schroeder, Jeffery A.
Year: 2006
Title: Effect of simulator motion on pilot behavior and perception
Journal: Journal of Aircraft
Volume: 43
Issue: 6
Date: November-December
Original Publication: AIAA 2005-6304, AIAA Modeling and Simulation Technologies Conference and Exhibit, San Francisco, CA, August 15-18, 2005.
Author's Title and Affiliation: Grant: Assistant Professor, University of Toronto Institute for Aerospace Studies, Toronto, Ontario M3H 5T6, Canada
Yam: Simulation Developer, Atlantis Systems International, 1 Kenview Boulevard, Brampton, Ontario L6T 5E6, Canada
Hosman: Director, AMS Consult, 2645 Delfgauw, The Netherlands
Schroeder: Chief (Acting), Aviation Systems Division, NASA Ames Research Center, Moffett Field, CA 94035
Abstract: A set of experiments were conducted on the University of Toronto Institute for Aerospace Studies flight research simulator to determine the effects of translational and yaw motion on pilot performance, workload, fidelity, pilot compensation, and motion perception for three helicopter yaw control tasks. The three control tasks were a yaw capture, a disturbance rejection task, and a tracking task. The yaw capture experiment was a duplication of an experiment previously run at a different simulator facility. The results of the yaw capture task were in general agreement with the previous study with the exception that, in the current study, yaw motion had a larger impact on pilot performance than the previous study. The current study found that translational motion improves performance and increases fidelity for all three tasks. Yaw motion increased performance for the yaw capture and disturbance rejection tasks. Translational motion generally improved fidelity and was easier to detect than yaw motion for all three tasks. Finally, if translational motion was present, the addition of yaw motion usually provided little additional benefit to performance, workload, compensation, or fidelity for all three tasks.

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Reference Type: Report
Author: Grantham, William D.
Year: 1989
Title: Comparison of flying qualities derived from in-flight and ground-based simulators for a jet-transport airplane for the approach and landing pilot tasks
City: Hampton, VA
Institution: National Aeronautics and Space Administration (NASA), Langley Research Center
Date: December
Type: Technical Report
Report Number: NASA TP-2962
Author's Title and Affiliation: Langley Research Center, Hampton, VA
Number of Pages: 31

Keywords: flying qualities, in-flight simulators, ground-based simulators, pilot performance, approach and landing
Abstract: The primary objective of this paper was to provide information to the flight controls/flying qualities engineer that will assist him in determining the incremental flying qualities and/or pilot-performance differences that may be expected between results obtained via ground-based simulation (and, in particular, the six-degree-of-freedom Langley Visual/Motion Simulator (VMS)) and flight tests. Pilot opinion and performance parameters derived from a ground-based simulator and an in-flight simulator are compared for a jet-transport airplane having 31 different longitudinal dynamic response characteristics. The primary pilot tasks were the approach and landing tasks with emphasis on the landing-flare task. The results indicate that, in general, flying qualities results obtained from the ground-based simulator may be considered conservative--especially when the pilot task requires tight pilot control as during the landing flare. The one exception to this, according to the present study, was that the pilots were more tolerant of large time delays in the airplane response on the ground-based simulator. The results also indicated that the ground-based simulator (particularly the Langley VMS) is not adequate for assessing pilot/vehicle performance capabilities (i.e., the sink rate performance for the landing-flare task when the pilot has little depth/height perception from the outside scene presentation).

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Reference Type: Journal Article
Author: Graybiel, A.; Miller, E. F.; Newsom, B. D.; Kennedy, R. S.
Year: 1968
Title: The effect of water immersion on perception of the oculogravic illusion in normal and labyrinthine-defective subjects
Journal: Acta Oto-Laryngologica
Volume: 65
Issue: 6
Pages: 599-610
ISSN: 0001-6489 (Print)
Number of Pages: 12
Accession Number: 1970-07121-001
Keywords: oculogravic illusion perception, water immersion, labyrinthine-defective Ss
Abstract: The separate and combined influences of otolith and nonotolith sensory inputs upon perception of the oculogravic illusion were studied by manipulating the visual and gravitoinertial force environments. By comparing the visually perceived direction of space by 4 naval aviators and 4 deaf persons with bilateral labyrinthine defects when dry and when immersed in water up to neck level, the contributions of (a) field force receptors in the vestibular organs, and (b) nonvestibular proprioceptors stimulated by external contact support could be differentiated. Under these various conditions it was found that in normal persons, the vestibular contribution is predictable in terms of the direction of the gravitoinertial force vector but that the nonvestibular contribution varies; it may be relatively great or small. In persons with bilateral labyrinthine defects, a nonvestibular contribution was always present, but there was great individual variance. The significance of the findings in terms of tests measuring the function of the otolith organs is discussed.

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Reference Type: Conference Paper
Author: Green, Mavis F.
Year: 2000
Title: Aviation instruction through flight simulation: Enhancing pilot decision-making skills
Conference Name: Flight Simulation - The Next Decade
Conference Location: London, UK
Publisher: Royal Aeronautical Society (RAeS)
Date: May 10-12
Author's Title and Affiliation: Embry-Riddle Aeronautical University, Daytona Beach, FL
Number of Pages: 8

Abstract: Information was collected form collegiate aviation programs to answer the research question: What type(s) of learning best explain how learners are socialized to aviation through the use of simulation technology? This is important because the use of appropriate educational strategies in training devices could provide ways to enhance pilot judgment as well as increase technical skills. Data from this study showed confusion and inconsistency on the parts of instructors implementing this instruction. Risk perception is identified as an important element in choosing instructional strategies. Cognitive apprenticeship is explored as an appropriate type of learning in high-risk fields.

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Reference Type: Conference Paper
Author: Green, Steven
Year: 2000
Title: Ab-initio simulation in the 21st century
Conference Name: Flight Simulation - The Next Decade
Conference Location: London, UK
Publisher: Royal Aeronautical Society (RAeS)
Date: May 10-12
Author's Title and Affiliation: Head of Training, BAE Systems Flight Training (Europe) S.L., Jerez, Spain
Number of Pages: 6
Abstract: Despite the development in manned flight in the 20th century, flight simulation is still in its infancy. This paper reviews the future simulator contribution to ab-initio airline pilot training.
It will ask if zero flight time training will be a practical proposition in the next century and examines areas which can be successfully exploited by low-cost high-fidelity training devices. It will also address the impact of new technologies such as virtual reality and helmet-mounted displays.
Given the correct learning and operating environment, it is the view of the author that zero flight time training will be possible. It probably is today, but practicalities preclude it.
Simulation increases the objectivity of both flight training and assessment. Helmet-mounted technology and virtual reality will reduce dependence on complex electro-mechanical devices. Such training will require Airline and Regulator to co-operate actively and contribute, whilst Flight Training Organizations (FTOs) will develop innovative solutions to evaluate trainees' capacity, decision-making processes and hand/eye coordination.
Currently, the cost-effective utilization of an FFS (Full Flight Simulator) is beyond most FTOs, but innovation with PC Technology will provide solutions. For example, a partnership between an FTO and a company specializing in low-cost PC-based simulation to meet Joint Aviation Authorities (JAA) requirements will be discussed.
The paper will also look at trials of helmet-mounted displays and their application to flight training, the value of motion *versus* visual, and the need for programmable machines rather than type-specific FFS. Finally, real-time ATC/traffic environment will be interfaced with the training device.
Training must be more effective, safer and cheaper than current practice. A challenge in a conservative industry working on the traditional basis that a good scare is worth more to man than advice. However, there will be enthusiasm from industry for a better and cheaper product, which understands that "experience is not what happens to a man, but what a man does with what happens to him."
Pilots can be trained as crew-people; the piston/jet interface removed and Crew Resource Management (CRM) and Company Operating Philosophies introduced from the beginning. Much of the instruction will actually be delivered by Computer Based Training. Safety will be enhanced in training because there will be no physical risk from technical or human malfunction, the trainee passing directly into a supervised multi-crew environment.
Training effectiveness, cost-effectiveness and learning transfer effectiveness will be enhanced. Controlled evaluation will take place in a partnership of FTOs, Regulators and Industry. Ab-initio flight training in simulated devices will focus on providing experience about making decisions. It is this new approach which will really contribute to flight safety in the next century.

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Reference Type: Report
Author: Griffin, M. J.
Year: 1991
Title: Physical characteristics of stimuli provoking motion sickness
Series Editor: (AGARD), Advisory Group for Aerospace Research and Development
Series Title: Motion Sickness: Significance in Aerospace Operations and Prophylaxis
Pages: 3-1 - 3-32
Type: Paper from AGARD Lecture Series 175
Author's Title and Affiliation: Human Factors Research Unit, Institute of Sound and Vibration Research, University of Southampton, Southampton, S09 5NH England
Number of Pages: 33
Abstract: The physical characteristics of motion stimuli responsible for motion sickness are reviewed in two parts. The provocative stimuli are categorized and their nauseogenic properties discussed qualitatively in terms of the sensory conflict theory of motion sickness. Quantitative information available from experimental studies with specific types of motion is then summarized. The motions of the body considered in this review include translational oscillation, swing motions, rotation about a vertical axis, rotation about an off-vertical axis, rotational oscillation and cross-coupled (i.e. coriolis) stimulation. Conditions producing visually-induced motion sickness are also summarized.

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Reference Type: Thesis
Author: Groen, Eric
Year: 1997
Title: Orientation to gravity: Oculomotor and perceptual responses in man
City: Utrecht, The Netherlands
University: Utrecht University
Advisor: Prof. Dr. W.A. van de Grind, Universiteit Utrecht; Dr. B. de Graaf, TNO Technische Menskunde
Thesis Type: Ph.D.
Keywords: human perception, spatial orientation
Abstract: This thesis concerns aspects of human spatial orientation, in particular the orientation with respect to gravity.
<u>Summary</u>
Chapter 1: In this chapter a new and automatic method was described to determine ocular torsion (OT) from digitized video images (Video-oculography). We developed this method based on the tracking of iris patterns. Instead of quantifying OT by means of cross-correlation of circular iris samples, which is commonly applied, this new method automatically selects and recovers a set of 36 significant patterns in the iris by a technique of template matching. Each relocated landmark results in a single estimate of the torsion angle. A robust algorithm estimates OT from this total set of individually determined torsion angles, thereby largely correcting for errors which may arise as due to misjudgments of the rotation center. In a prepared set of images of an artificial eye the new method reproduced OT with an accuracy of 0.1º. In a sample of 256 images of human eyes, a practical reliability of 0.25º was achieved.
Chapter 2: The objective of this experiment was to assess evidence for vestibular adaptation to prolonged hypergravity in human subjects as to substantiate previously described effects, such as postural imbalance and motion sickness (Sickness Induced by Centrifugation, SIC). We measured the ocular torsion response in eleven subjects during static and dynamic body tilt, once before and once after an one-hour centrifuge run of +3Gx. The OT response to static tilt (in the range of 0 to 57º to either side) showed a 10% decrease, suggesting a reduced otolith gain. The otolith-canal interaction was examined by comparing the dynamic OT response to sinusoidal body roll (frequency of 0.25 Hz and amplitude of 25º) about an earth-horizontal rotation axis (stimulation of both otoliths and canals) and about an earth-vertical rotation axis (stimulation of canals). After centrifugation, the gain of the slow component velocity increased in both conditions in all but four subjects, who showed a decrease in the supine condition (but not in the upright condition). These four subjects developed symptoms of SIC, so that the different behavior of their SCV gain was likely due to a declined state of alertness which specifically may have occurred in the supine condition. In addition to the OT data, the horizontal VOR was measured in response to a velocity step rotation about the vertical yaw axis. The mean gain of the horizontal VOR was

unaffected by centrifugation, but the dominant time constant was significantly reduced. Because the time constant of the horizontal VOR is centrally controlled by the velocity storage mechanism, this result provides evidence for vestibular adaptation at a central level.

Chapter 3: In the experiment of Chapter 2 the dynamic OT response (or torsional VOR) was measured to study possible effects of centrifugation on the canal-otolith interaction. However, the response did not show a clear otolith contribution. Supposedly, the stimulus frequency of 0.25 Hz had been too high to reveal an otolith component. The response was therefore studied in more detail at a wider frequency range. The ocular torsion response was examined during passive sinusoidal body roll in five human subjects. To separate the otolith organ and semicircular canal contributions, again the axis of rotation was varied between earth-horizontal and earth-vertical. At a fixed amplitude of 25°, the stimulus frequency was varied from 0.05 to 0.4 Hz. Additionally, at a fixed frequency of 0.2 Hz, the response was also measured at the amplitudes of 12.5° and 50°. The results showed that the gain and phase of the slow component velocity (SCV) did not depend on stimulus amplitude, indicating a linear response. Contribution of the otoliths affected the ocular torsion response in three different ways. First, the gain of the SCV was slightly but consistently higher during earth-horizontal rotation than during earth-vertical rotation. In the supine orientation the average gain increased from 0.10 to 0.26. In the upright orientation the average gain increased from 0.14 to 0.37. Second and more substantially, modulation of the otolith inputs improved the response dynamics by reducing the phase lead at frequencies up to 0.2 Hz. Third, the nystagmus showed considerably less anti-compensatory saccades in upright conditions than in supine conditions, even though the SCV gain was lower in the latter. As a consequence, the average excursion of torsional eye position was highest during earth-horizontal rotation. This effect was observed in the entire frequency range. Thus, the otoliths did not only control the torsional VOR at low stimulus frequencies by keeping the slow component in phase with head motion, but also in a wider frequency range by modulating the saccadic behavior as to increase the excursion range of torsional eye position. We conclude that, during head tilt, the primary concern of the otolith-oculomotor system is to stabilize eye position in space, rather than to prevent retinal blur. This confirms that tilt otolith-induced ocular responses subserve spatial orientation.

Chapter 4: This chapter describes a study on the effectiveness of a highly polarized visual environment to induce sensations of self-motion and self-tilt in a stationary observer. The subjects were immersed in an 8 foot cubic room which could be fully rotated about an earth-horizontal axis. The interior of the room was filled with common visual features such as a door, a window, and a great variety of objects which indicated up and down (visual polarity). When the room was tilted about the roll axis of an erect observer it produced illusory self-tilt by virtue of its visual polarity alone. Although the effect was larger than is known from the literature, the experienced self-tilt did not linearly increase with room tilt. At higher angles of room tilt (80 and 120º) the judgment of verticality became more variable and depended less on the visual scene. The room induced complete self-rotation in more than 80% of the cases when it was rotated at constant velocity about a stationary subject in various body positions. This strong effect was attributed to both its motion and its visual polarity.

Chapter 5: This chapter describes a study on the visual-vestibular interaction in the judgment of the body orientation relative to gravity. Illusory self-tilt and self-motion (vection) produced by rotation of a full-field non-polarized visual scene about the subject's roll axis was measured as a function of the presence or absence of actual rotation of the subject during visual acceleration. Subject rotation was at two levels of acceleration and with or without a delay between initial rotation and subsequent return (washout) to the vertical position. In one set of conditions, visual motion and self-motion were in opposite directions (concordant) [sic] and in another set they were in the same direction (discordant) [sic]. For concordant motion the main effect of body rotation was to reduce the time taken by the subject to indicate self-rotation. The magnitude of self-tilt was increased by actual body tilt as could be expected from addition of the perceived actual body tilt and illusory body tilt induced by visual rotation. This effect of augmented body tilt did not persist after the body was returned to the vertical. The magnitude of vection was not influenced by body rotation and washout. For discordant motion of the body and the visual scene, subjects were confused and their responses were very variable. This suggests a non-linear visual-vestibular interaction, in which perceived self-tilt and self-motion are strongly determined by visual inputs, except for discordant accelerations of the body and the visual surroundings. Then the perception is determined by the vestibular inputs.

Notes: In book form; URL is no longer working (9/30/09).

URL: http://www.desc.med.vu.nl/Publications/Thesis/Groen/Groen.htm

Reference Type: Report
Author: Groen, E. L.; Bles, W.
Year: 1999
Title: Pitch tilt as motion cue for the simulation of linear horizontal acceleration
City: Soesterberg, The Netherlands
Institution: TNO Human Factors Research Institute
Date: April 26
Type: TNO-report
Report Number: TM-99-B005
Number of Pages: 25
Abstract: In the present study we examined to which extent pitch motion may be used as motion cue to passive linear fore aft motion. In total, 15 subjects had to judge the simulation of sinusoidal motion profiles at four different frequencies between 0.04 and 0.33 Hz, and at three different amplitudes of visual acceleration (0.44, 0.88 and 1.76 m/s^2). Psychometric curves were calculated in order to determine: 1) at which minimum tilt amplitude the simulation was perceived as veridical in more than 50% of the cases, and 2) the maximum tilt amplitude at which tilting was perceived as rotation in more than 50% of the cases. The results show that at all frequencies proprioceptive stimulation improved the motion sensation. The minimally required pitch amplitude showed a negative relationship with the log stimulus frequency and depended on the visually simulated displacement. In addition, the detection threshold for rotation depended on the tilt rate, and was remarkably increased by the linear visual stimulus. As a consequence, the optimum tilt range narrowed toward higher frequencies. In conclusion, pitch tilt can be used effectively as motion cue to simulated fore aft motion.

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Reference Type: Journal Article
Author: Groen, Eric. L; Clari, Mario S. V. Valenti; Hosman, Ruud J. A. W.
Year: 2001
Title: Evaluation of perceived motion during a simulated takeoff run
Journal: Journal of Aircraft
Volume: 38
Issue: 4
Pages: 600-606
Author's Title and Affiliation: TNO Human Factors, 3769 ZG Soesterberg, The Netherlands
Number of Pages: 7
Abstract: The range of motion stimuli that produce realistic sensations of longitudinal acceleration during a simulated takeoff run in a research simulator are presented. In all conditions, the visually simulated motion profile consisted of a step acceleration of 0.35g. The gains of the translational (surge) and tilt-coordination channel (pitch) were systematically varied. The linear travel of the motion platform was kept constant by covarying the bandwidth with the gain of the high-pass surge filter. Rate and acceleration limit of tilt coordination were fixed at 0.052 rad/s and 0.052 rad/s^2, respectively. Using a two-alternative-forced-choice paradigm, seven experienced pilots judged their motion perception as pilots non-flying. Based on their subjective response, psychometric curves were constructed. Pilots' judgments were negatively influenced by any perceived discontinuity between the initial surge stimulus and the sustained pitch stimulus. The range of realistic motion parameters was centered around a gain of 0.2 and natural frequency of 0.73 rad/s for the surge filter and a gain of 0.6 for the low-pass pitch filter. Remarkably, unity gains were rejected as too powerful. Therefore, it is concluded that, for the typical hexapod platform, the takeoff maneuver can be more effectively simulated by providing less than the full mathematical model acceleration.

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Reference Type: Conference Paper
Author: Groen, Eric L.; Hosman, Ruud J.A.W.; Dominicus, Jacco W.
Year: 2003

Title: Motion fidelity during a simulated takeoff
Conference Name: AIAA Modeling and Simulation Technologies Conference
Conference Location: Austin, Texas
Publisher: American Institute of Aeronautics and Astronautics (AIAA)
Date: August 11-14
Electronic Resource Number: AIAA 2003-5680
Number of Pages: 11
Abstract: In this psychophysical study, seven airline pilots reported on their perceived self-motion to variations of motion filter gains during a simulated takeoff. Each pilot participated both as pilot flying and pilot non-flying. In order to vary the gains of the simulated linear acceleration and the rotation independently, a "direct pitch" filter was used. Simulator pitch tilt was applied to simulate the low-pass filtered linear acceleration, whereas unfiltered pitch motion was used to simulate motion. The study took place in a four degrees-of-freedom research flight simulator. Subjective data showed that the perception of longitudinal acceleration was determined by the tilt-coordination. On average, pilots flying preferred larger tilt-coordination gains than pilots non-flying. Motion perception during rotation depended completely on the simulator pitch rate, which also determined the perceived attitude in the subsequent climb. No interactions were found between the effects of the tilt-coordination and the rotation. Objective simulator data showed that the aircraft control improved with increasing gain of the simulated rotation. We conclude that during the simulation of the takeoff maneuver of transport aircraft high gains (≥0.75) for the tilt coordination and rotation filters should be applied to support pilot's perception and control behavior.

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Reference Type: Conference Proceedings
Author: Groen, E. L.; Smaïli, M. H.; Hosman, R. J. A. W.
Year of Conference: 2005
Title: Simulated decrab maneuver: Evaluation with a pilot perception model
Conference Name: AIAA Modeling and Simulation Technologies Conference and Exhibit
Conference Location: San Francisco, CA
Publisher: American Institute of Aeronautics and Astronautics (AIAA)
Date: August 15-18
Electronic Resource Number: AIAA 2005-6108
Author's Title and Affiliation: Groen: Aerospace Physiologist, Education and Training Department, TNO Human Factors
Smaïli: Aerospace Engineer; Training, Human Factors and Cockpit Operations Department, National Aerospace Laboratory
Hosman: Pilot Engineer, AMS Consult
Number of Pages: 13
Abstract: In this simulator study eleven pilots rated their motion perception during a series of decrab maneuvers of a twin-engine passenger aircraft. Platform yaw, sway, and roll motion were varied independently to examine their relative contribution to the pilots' judgments. In one set of conditions, the washout algorithms were bypassed so as to reproduce unfiltered aircraft motion. This was compared with the washout-filtered motion in another set of conditions. Moreover, the effect of visual cues was studied by testing the unfiltered motion cues once under simulated VMC, and once under IMC. The results show that the simulation of heading alignment was positively affected by platform sway and roll, and also by the visual stimulus. Platform yaw was poorly recognized, and remained under the perceptual threshold in the presence of platform sway. Interestingly, unfiltered sway motion was perceived as too strong, even though the simulator workspace required downscaling to 70% of the actual aircraft motion. Finally, the subjective data was used to validate our human motion perception model. Due to the fact that the model does not yet account for the observed interaction between sway motion and the perceptual threshold for yaw, the model output did not quantitatively correlate with the magnitude ratings. However, a multiple regression analysis showed that, qualitatively, the model did predict the way pilots interpreted the platform motion. We conclude that better understanding of perceptual thresholds in a flight simulator setting is necessary to enable quantitative analysis of the effectiveness of ground-based motion cues.
Author Address: Groen: TNO Human Factors, Education and Training Department, P.O. Box 23, 3769 ZG Soesterberg, The Netherlands

Smaïli: National Aerospace Laboratory; Training, Human Factors and Cockpit Operations Department, P.O. Box 90502, 1006 BM, Amsterdam, The Netherlands
Hosman: AMS Consult, Dijkgraafstraat 26, 2645 KN Delfgauw, The Netherlands

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Reference Type: Conference Proceedings
Author: Groen, Eric L.; Wentink, Mark; Trujillo, Maite; Huhne, Rolf
Year of Conference: 2008
Title: Ground-based simulation of upset recovery in DESDEMONA: Aspects of motion cueing and motion perception
Conference Name: AIAA Modeling and Simulation Technologies Conference
Conference Location: Honolulu, HI
Publisher: American Institute of Aeronautics and Astronautics (AIAA)
Date: August 18-21
Electronic Resource Number: AIAA 2008-6869
Author's Title and Affiliation: Groen and Wentink: TNO Defence, Security and Safety, Soesterberg, the Netherlands
Trujillo: Boeing Research and Technology Europe, Madrid, Spain
Huhne: AMST, Ranshofen, Austria
Keywords: Desdemona, upset recovery training (URT)
Abstract: Unsuccessful recovery from unusual flight attitudes, or "airplane upset", is considered an important factor in civil aviation accidents. It is generally recognized that there is a clear need for enhanced training of recovery procedures from unusual flight attitudes, i.e. situations where an aircraft unintentionally exceeds the parameters of the normal flight envelope. Exercising these conditions in the real world is unsafe, expensive and, if performed in smaller aircraft, not representative of the situation in commercial aircraft. Ground-based simulation of these extreme conditions is an interesting alternative for pilot instruction. However, at present, hexapod-based flight simulators used for pilot training are not certified for this purpose. Desdemona, a novel simulation facility, offers an extended motion envelope with enhanced motion capabilities which may prove adequate to simulate upset recovery events. The six degrees-of-freedom motion system features a gimbaled gondola which allows for unlimited rotation about three axes. In addition, the gondola can move up and down along a 2m long heave axis, and horizontally along an 8m long linear track. This track can be rotated on a planetary axis so as to produce a sustained linear acceleration up to 3G. The cockpit contains a projection system for out-the-window imagery, and can be reconfigured into different cockpit layouts. Desdemona has become operational in January 2008. This paper discusses the preliminary concepts for the simulation of upset recovery conditions based on the unique Desdemona motion features. This paper also introduces the motion envelope of upset conditions in support of pilot training.

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Reference Type: Journal Article
Author: Grunfeld, E. A.; Morland, A. B.; Bronstein, A. M.; Gresty, M. A.
Year: 2000
Title: Adaptation to oscillopsia: A psychophysical and questionnaire investigation
Journal: Brain
Volume: 123
Pages: 227-290
Author's Title and Affiliation: Grunfeld, Bronstein, and Gresty: Medical Research Council Human Movement and Balance Unit, National Hospital for Neurology and Neurosurgery, London
Morland: Psychology Department, Royal Holloway, University of London, Egham, UK
Number of Pages: 14
Keywords: vestibular, handicap, retinal slip, motion perception
Abstract: In this study we explore the reasons why patients with bilateral vestibular failure report disparate degrees of oscillopsia. Twelve bilateral labyrinthine-defective (LD) subjects and twelve normal healthy controls were tested using a self- versus visual-motion psychophysical experiment. The LD

subjects also completed a questionnaire designed to quantify the severity of handicap caused by oscillopsia. Additional standardized questionnaires were completed to identify the role of personality, personal beliefs and affective factors in adaptation to oscillopsia. During the psychophysical experiment subjects sat on a motorized Barany chair whilst viewing a large-field projected video image displayed on a screen in front of them. The chair and video image oscillated sinusoidally at 1 Hz in counterphase at variable amplitudes which were controlled by the subject but constrained, so that the net relative motion of the chair and video image always resulted in a sinusoid with a peak velocity of 50 deg/s. The subject's task was to find the ratio of chair versus video image motion that subjectively produced the 'most comfortable visual image'. Eye movements were recorded during the experiment in order that the net retinal image slip at the point of maximum visual comfort could be measured. The main findings in the LD subjects were that, as a group, they selected lower chair motion amplitude settings to obtain visual comfort than did the normal control subjects. Responses to the questionnaires highlighted considerable variation in reported handicap due to oscillopsia. Greater oscillopsia handicap scores were significantly correlated with a greater external locus of control (i.e. the perception of having little control over one's health). Retinal slip speed was negatively correlated with oscillopsia handicap score so that patients who suffered the greatest retinal slip were those least handicapped by oscillopsia. The results suggest that adaptation to oscillopsia is partly related to the patient's personal attitude to the recovery process and partly associated with the development of the tolerance to the movement of images on the retina during self-motion. The later is likely to be related to previously described changes in visual motion sensitivity in these patients.

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Dr. A. B. Morland, Psychology Department, Royal Holloway, University of London, Egham, Surrey TW20 0EX, UK

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Reference Type: Journal Article
Author: Guckenberger, Dutch; Guckenberger, Liz; Luongo, Frank; Stanney, Kay; Sepulveda, Jose
Year: 1995
Title: Above-real-time training and the hyper-time algorithm
Journal: Dr. Dobb's Journal
Pages: 52-60
Date: April
Author's Title and Affiliation: D. Guckenberger: Senior Software Engineer, ECC International
L. Guckenberger: Research Associate, University of Central Florida
Stanney, Sepulveda: Associate Professors, University of Central Florida, Industrial Engineering Department
Luongo: Software Engineer, ECC International
Number of Pages: 5
Abstract: The hyper-time algorithm lets you alter the flow of `simulated time' to benefit users -slower than real time can be used for novice users, while faster than real time can be used for experts or persons `time surfing' over uninteresting portions of information. Applying the algorithm to `Above-Real-Time Training' also improves human performance, increases retention and training-device effectiveness, and decreases strength.

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Reference Type: Report
Author: Guedry, Fred E.; Benson, Alan J.
Year: 1976
Title: Coriolis Cross-Coupling Effects: Disorienting and Nauseogenic or Not?
City: Pensacola, FL
Institution: Naval Aerospace Medical Research Laboratory
Report Number: NAMRL-1231
Author's Title and Affiliation: Guedry: Naval Aeropsace Medical Research Laboratory

Benson: RAF Institute of Aviation Medicine, Farmborugh, England
Keywords: disorientation, motion sickness, Coriolis effects, vestibular stimulation
Abstract: Nausea, vomiting, and disorientation are sometimes produced by head movements during turning maneuvers in aircraft. These responses are usually attributed to Coriolis cross-coupling stimulation of the vestibular system, although it has been indicated recently that many turning maneuvers in aircraft have insufficient angular velocity to generate such effects. The purpose of the study was to further distinguish conditions in which Coriolis cross-coupling effects are disorienting and nauseogenic from conditions in which they are neither disorienting nor nauseogenic.
When head tilts are executed during angular acceleration which commences a turn, vestibular stimulation is neither disorienting nor nauseogenic. During constant speed turns and during deceleration which stops such turns, Coriolis cross-coupling effects can be disorienting and nauseogenic if the angular velocity of the turning vehicle is of sufficient magnitude at the time the head movement is made.
URL: http://stinet.dtic.mil/oai/oai?&verb=getRecord&metadataPrefix=html&identifier=ADA036899

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Reference Type: Conference Proceedings
Author: Guedry, Fred E. Jr.
Year of Conference: 1987
Title: Technical evaluation report
Conference Name: Aerospace Medical Panel Symposium on Motion Cues in Flight Simulation and Simulator Induced Sickness
Conference Location: Brussels, Belgium
Publisher: Advisory Group for Aerospace Research and Development (AGARD)
Pages: 0-7 - 0-14 (vii-xiv)
Date: September 29-October 2
ISBN: AGARD-CP-433
Author's Title and Affiliation: M.S., Ph.D., Chief Scientist, Naval Aerospace Medical Research Laboratory, Pensacola, FL
Number of Pages: 8
Keywords: simulator sickness, motion sickness, simulator training, simulator after-effects, simulator design trends
Abstract: The proceedings include seven papers, ensuing discussions of the papers, and a Round Table Discussion from the Symposium sponsored by AGARD Aerospace Medical Panel held in Brussels, Belgium, on September 28 to October 2, 1987. The frequency of reports of undesirable effects associated with simulator training has increased to offset the higher costs and risks of conducting training in the complex modern aircraft. Review of current and anticipated future trends in simulator design features suggests that additional problems will arise if research on the etiology of simulator-induced motion sickness and other unwanted simulator effects is insufficient to counteract problems before they arise. The objective of this symposium was to examine simulator-induced effects, their optimal implications, and their etiology in order to develop ideas for reducing undesired effects. The papers in this symposium address present and anticipated trends in simulator design, a theoretical viewpoint underlying many of the studies of simulator effects, characteristics of simulators associated with undesired effects, surveys of simulator-induced effects, models for the design and evaluation of simulators, and perceptual and neuropsychological functions fundamental to the understanding of simulation. These papers and the accompanying discussion provide a summary of information obtained in recent years on simulation, and guidelines for direction of future research.
URL: http://handle.dtic.mil/100.2/ADA202492

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Reference Type: Journal Article
Author: Guerraz, M.; Yardley, L.; Bertholon, P.; Pollak, L.; Rudge, P.; Gresty, M. A.; Bronstein, Adolfo. M.
Year: 2001
Title: Visual vertigo: Symptom assessment, spatial orientation, and postural control
Journal: Brain: A Journal of Neurology
Volume: 124
Issue: 8
Pages: 1646-1656
Date: 2001
ISSN: 0006-8950
Number of Pages: 11
Accession Number: 2001-07867-008
Keywords: visual vertigo, symptoms, spatial orientation, postural control
Abstract: Assessed symptoms, anxiety and the influence of disorienting visual stimuli in 21 patients (aged 21–60 yrs) with visual vertigo (VV). A peripheral vestibular disorder was diagnosed in 17 out of 21 patients. 16 bilateral labyrinthine-defective (LD) and 25 normal Ss served as controls. Levels of trait anxiety and childhood motion sickness in the 3 groups were not significantly different. Reporting of autonomic symptoms and somatic anxiety was higher than normal in both patient groups but not significantly different between LD and VV Ss. Reporting of vestibular symptoms was higher in VV than in LD Ss. Ss were required to set the subjective visual vertical in total darkness, in front of a luminous tilted frame (TF), and in front of a disc rotating in the frontal plane. Body sway was measured with eyes closed, eyes open (EO), facing the TF, and during disc rotation. Both LD and VV Ss showed: a significant increase in the tilt of the visual vertical with the static TF and the rotating disc (RD); and an increased postural deviation while facing the TF and RD. The ratio between sway path with eyes closed and EO was increased in the LD, but not in VV Ss, compared with normal Ss. The ratio between sway path during disc rotation and sway path during EO was increased in VV but not in LD Ss.

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Reference Type: Generic
Author: Guinn, J.
Year: 1997
Title: FAA/ICAO pilot/controller phraseology & definitions
Type of Work: student research
Keywords: FAA pilot controller glossary, ICAO, ATC, pilot, communication
Abstract: Guinn performed a comparative analysis of pilot/controller phraseology from the FAA pilot/controller glossary and ICAO Document 9569.

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Reference Type: Journal Article
Author: Gum, D. R.; Albery, W. B.
Year: 1976
Title: Time-delay problems encountered in integrating the advanced simulator for undergraduate pilot training
Journal: Journal of Aircraft
Volume: 14
Issue: 4
Pages: 327-332
Author's Title and Affiliation: Gum and Albery: Air Force Human Resources Laboratory, Wright-Patterson Air Force Base
Number of Pages: 6
Abstract: An advanced Computer Image Generation (CIG) visual system has been integrated with an advanced Flight Training Research Simulator. The integration design was the first developed for integrating a CIG visual system with a sophisticated flight simulator. There was much concern for the unique CIG system transport delay, and techniques were developed which proved to be quite successful

in compensating for the majority of this delay. However, not enough concern was given to previously unrecognized and unreported excessive motion system delays which were encountered during final integrated system tests. The integration scheme and the impact of iteration rates, visual and motion system delays, and delay compensation on visual and motion cue coordination as perceived by pilots are presented.

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Reference Type: Conference Paper
Author: Gundry, John
Year: 1976
Title: Man and motion cues
Conference Name: Third Flight Simulation Symposium
Conference Location: London
Publisher: Royal Aeronautical Society (RAeS)
Date: April
Author's Title and Affiliation: R.A.F. Institute of Aviation Medicine, Farnborough, Hants.
Number of Pages: 20
Abstract: No abstract.

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Reference Type: Conference Paper
Author: Guo, Liwen; Cardullo, Frank M.; Houck, Jacob A.; Kelley, Lon C.; Wolters, Thomas
Year: 2004
Title: New predictive filters for compensating the transport delay on a flight simulator
Conference Name: AIAA Modeling and Simulation Technologies Conference and Exhibit
Conference Location: Providence, RI
Publisher: American Institute of Aeronautics and Astronautics (AIAA)
Date: August 16-19
Electronic Resource Number: AIAA 2004-5441
Author's Title and Affiliation: Guo: PhD Candidate, Department of Mechanical Engineering, State University of New York at Binghamton, Binghamton, NY
Cardullo: Professor, Department of Mechanical Engineering, State University of New York at Binghamton, Binghamton, NY
Houck: Assistant Branch Head, NASA Langley Research Center, Hampton, VA
Kelly: Software Engineer, Unisys Corp., Hampton, VA
Wolters: Computer Engineer, NASA Langley Research Center, Hampton, VA
Number of Pages: 13
Keywords: transport delay, delay compensation, lead/lag filer, McFarland filter, Sobiski/Cardullo filter
Abstract: The problems of transport delay in a flight simulator, such as its sources and effects, are reviewed. Then their effects on a pilot-in-the-loop control system are investigated with simulations. Three current prominent delay compensators--the lead/lag filter, McFarland filter, and the Sobiski/Cardullo filter were analyzed and compared. This paper introduces two novel delay compensation techniques--an adaptive predictor using the Kalman estimator and a state space predictive filter using a reference aerodynamic model. Application of these two new compensators on recorded data from NASA Langley Research Center Visual Motion Simulator show that they achieve better compensation over the current ones.

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Reference Type: Conference Paper
Author: Guo, Liwen; Cardullo, Frank M.; Houck, Jacob A.; Kelly, Lon C.; Wolters, Thomas E.
Year: 2005
Title: A comprehensive study of three delay compensation algorithms for flight simulators
Conference Name: AIAA Modeling and Simulation Technologies Conference and Exhibit

Conference Location: San Francisco, CA
Publisher: American Institute of Aeronautics and Astronautics (AIAA)
Date: August 15-18
Electronic Resource Number: AIAA 2005-5896
Author's Title and Affiliation: Guo: Postdoctoral researcher, Department of Mechanical Engineering, State University of New York at Binghamton, Binghamton
Cardullo: Professor, Department of Mechanical Engineering, State University of New York at Binghamton, Binghamton
Houck: Branch Head, NASA Langley Research Center, Hampton, VA
Kelly: Software Engineer, Unisys Corp., Hampton, VA
Wolters: Computer Engineer, NASA Langley Research Center, Hampton, VA
Number of Pages: 15
Keywords: time delay, delay compensation, compensation algorithms, McFarland filter, Adaptive predictor, State Space predictor
Abstract: This paper summarizes a comprehensive study of three predictors used for compensating the transport delay in a flight simulator; The McFarland, Adaptive and State Space Predictors. The paper presents proof that the stochastic approximation algorithm can achieve the best compensation among all four adaptive predictors, and intensively investigates the relationship between the state predictor's compensation quality and its reference model. Piloted simulation tests show that the adaptive predictor and state space predictor can achieve better compensation of transport delay than the McFarland predictor.

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Reference Type: Conference Paper
Author: Guo, L.; Cardullo, F. M.; Telban, R. J.; Houck, J. A.; Kelley, L. C.
Year: 2003
Title: The results of a simulator study to determine the effects on pilot performance of two different motion cueing algorithms and various delays, compensated and uncompensated
Conference Name: AIAA Modeling and Simulation Technologies Conference and Exhibit
Conference Location: Austin, TX
Publisher: American Institute of Aeronautics and Astronautics (AIAA)
Date: August 11-14
Electronic Resource Number: AIAA-2003-5676
Author's Title and Affiliation: Liwen Guo, Frank M. Cardullo, Robert J. Telban: Department of Mechanical Engineering, State University of New York, Binghamton, NY
Jacob A. Houck: Manager, Cockpit Motion Facility, Associate Fellow, NASA Langley Research Center, Hampton, VA
Lon C. Kelly: Unisys Corp., Hampton, VA
Number of Pages: 12
Abstract: A study was conducted employing the Visual Motion Simulator (VMS) at the NASA Langley Research Center, Hampton, Virginia. This study compared two motion cueing algorithms, the NASA adaptive algorithm and a new optimal control based algorithm. Also, the study included the effects of transport delays and the compensation thereof. The delay compensation algorithm employed is one developed by Richard McFarland at NASA Ames Research Center. This paper reports on the analyses of the results of analyzing the experimental data collected from preliminary simulation tests. This series of tests was conducted to evaluate the protocols and the methodology of data analysis in preparation for more comprehensive tests which will be conducted during the spring of 2003. Therefore only three pilots were used. Nevertheless some useful results were obtained.
The experimental conditions involved three maneuvers; a straight-in approach with a rotating wind vector, an offset approach with turbulence and gust, and a takeoff with and without an engine failure shortly after liftoff. For each of the maneuvers the two motion conditions were combined with four delay conditions (0, 50, 100 & 200 ms), with and without compensation.
Discrete time domain data of different variables were recorded and the Cooper-Harper Ratings (CHR) of simulator handling qualities were logged from the debriefing of the pilots who “flew” the simulator for the experiments. These two categories of data, allow both objective and quasi-objective evaluation, of the

human controllers' performance. Power Spectral Density (PSD), an approach in the frequency domain was adopted for the analysis of the objective data. The PSD of the operator control behavior is an excellent indicator of operator workload. Among the analyses employing the PSD are the integral of the PSD over selected intervals and the analysis determining the frequency at which the peaks of the PSD occur.

From the analyses of the power spectral density, the total PSD of roll stick and pitch stick control in the 0 to 1 Hz range is slightly smaller when the optimal motion cueing algorithm is used in the straight-in approach and the offset approach. There is no noticeable difference of the total PSD of the pedal between the adaptive and the optimal motion cueing algorithms. When time delay is inserted, the total PSD of the roll stick, pitch stick and pedal control increases in the 0 to 1 Hz range, and increases significantly in the 0.17 to 0.4 Hz portion of the spectrum. Time delay also moves the highest peak of the PSD of the roll stick to a higher frequency area. Compensation reduces the total PSD, increased by the time delay, especially in the 0 to 0.4 Hz range. It also shifts the highest peak of PSD back to relatively lower frequencies. The paper will present details of the analysis including graphical representations of the results.

From the analyses of Cooper-Harper ratings, the optimal motion cueing algorithm shows better performance over the adaptive algorithm. The CHR does not increase when a time delay of up to 100 ms is presented. The mean CHR across all pilots in the straight-in approach and offset approach increases when compensation is applied, and the handling qualities rating becomes worse with compensation as delay increases. The compensation brings the mean CHR down only in the takeoff maneuver.

The paper describes the motion cueing algorithms used as well as the details of the manner in which the delays were inserted. The McFarland compensation algorithm will also be described.

URL: http://library-dspace.larc.nasa.gov/dspace/jsp/bitstream/2002/12425/1/NASA-aiaa-2003-5676.pdf

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Reference Type: Conference Proceedings
Author: Hagiwara, Toshimasa; Advani, Sunjoo K.; Funabiki, Kohei; Wakairo, Kaoru; Muraoka, Koji; Nojima, Takuya
Year of Conference: 2008
Title: Evaluating an objective method for motion cueing fidelity
Conference Name: AIAA Modeling and Simulation Technologies Conference
Conference Location: Honolulu, HI
Publisher: American Institute of Aeronautics and Astronautics (AIAA)
Date: August 18-21
Electronic Resource Number: AIAA 2008-6542
Author's Title and Affiliation: Hagiwara, Funabiki, Wakairo, Muraoka, Nojima: Research Engineers, JAXA Flight Research Center, Japan Aerospace Exploration Agency, Mitaka City, Tokyo, Japan
Advani: President, International Development of Technology (IDT) b.v., Breda, The Netherlands
Abstract: The relationship between the motion fidelity of a flight simulator and pilot handling quality was investigated through a series of pilot-in-the-loop simulations. The phase margin of the aircraft-pilot system during a high gain tracking task was measured while varying the gain and filtering parameters of the motion cueing algorithm, and then compared with Advani-Hosman's criterion of motion fidelity. Although the results of the simulation are limited to only two axes of the six degrees of freedom, and limited by some hardware limitations, the results partially support the suitability of the criterion of quantifying and qualifying flight simulator motion cueing system.

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Reference Type: Book Section
Author: Hain, Timothy C.; Zee, Davis S.
Year: 1992
Title: Velocity storage in labyrinthine disorders
Editor: Cohen, Bernard; Tomko, David L.; Guedry, Fred E.
Book Title: Sensing and Controlling Motion: Vestibular and Sensorimotor Function
City: New York
Publisher: New York Academy of Sciences
Volume: 656
Pages: 297-304
Series Title: Annals of the New York Academy of Sciences
Original Publication: Conference proceedings, Sensing and Controlling Motion: Vestibular and Sensorimotor Function, July 7-11, 1991, Palo Alto, CA (sponsored by New York Academy of Sciences)
Author's Title and Affiliation: Hain: Departments of Neurology and Otolaryngology, Northwestern University School of Medicine, Chicago, IL 60616
Zee: Departments of Neurology, Opthalmology, Otolaryngology, and Neuroscience, The John Hopkins University School of Medicine, Baltimore, MD 21205
Number of Pages: 8
Abstract: We studied 13 patients with unilateral peripheral vestibular lesions following removal of acoustic neurinomas. The time constant of the VOR after surgery was 6.4 +/- 2.6 seconds (normal is 18.5 +/- 7.7 seconds). The time constant of OKAN after surgery was 7.2 +/- 1.8 seconds (normal is 11.3 +/- 3.2 seconds). The mean initial velocity of OKAN after surgery was 9.7 +/- 2.4 deg/second (normal is 11.7 +/- 5.9 deg/second). These data suggest that unilateral peripheral vestibular loss is associated with a complete loss of velocity storage for canal input but only a partial loss of velocity storage for visual input. These results can be accounted for by current mathematical models of the velocity storage mechanism.
Notes: Research supported by grants from National Institutes of Health, U.S. Public Health Service
Author Address: Timothy C. Hain, Northwestern Memorial Hospital, Department of Neurology, Passavant 10, 303 East Superior, Chicago IL 60611

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Reference Type: Conference Paper
Author: Hall, J. R.
Year: 1978
Title: Motion versus visual cues in piloted flight simulation
Conference Name: Flight Mechanics Panel Specialists' Meeting on Piloted Aircraft Environment Simulation Techniques
Conference Location: Brussels, Belgium
Publisher: Advisory Group for Aerospace Research and Development (AGARD)
Date: April 24-27
Author's Title and Affiliation: Flight Systems Department, Royal Aircraft Establishment, Bedford, Bedfordshire, UK
Number of Pages: 13
Keywords: motion, vision cues, roll, surge, peripheral
Abstract: In the ground based simulation of piloted flight the provision of "adequate" cues to the pilot is essential for both training and the successful evaluation of handling and ride qualities. Realistic motion cues are particularly difficult to provide and attempts to justify other techniques are frequently made in order to provide the pilot with, subjectively at least, a realistic handling task. This paper presents two examples to show that motion cues can be vital even when "adequate" alternative visual cues are available. The first shows that practical, low gain, roll motion cues are better than nominally perfect peripheral vision cues for controlling a vehicle with an unstable dutch roll mode and the second that motion can be vital even for developing items such as head-up displays for which it might not at first sight seem necessary.
This paper concludes that for the prediction and evaluation of handling qualities using a piloted flight simulator it is not always sufficient for the pilot to achieve a similar performance in the simulator as in flight; it is also necessary that he should adopt the same control strategy. To achieve this it is often essential to provide the pilot with motion cues as no substitute in these circumstances has yet been found.

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Reference Type: Report
Author: Hall, J. R.
Year: 1989
Title: The need for platform motion in modern piloted flight training simulators
City: Bedford, UK
Institution: Royal Aerospace Establishment
Date: October
Type: Technical Memorandum
Report Number: Tech Memo FM 35
Number of Pages: 16
Keywords: platform motion, motion cueing, training simulators, (flight simulators, human factors engineering, flight simulations, Great Britain)
Abstract: This paper discusses motion cueing in piloted flight training simulators, and presents the factors that must be taken into account when assessing the need for, and benefits of, a motion platform so that informed decisions can be taken as to its training value. These factors include the role of the simulator, the handling qualities of the vehicle concerned, the tasks the pilot is required to fly, the performance he is expected to achieve and whether training considerations require him to use a similar control strategy and control activity in the simulator as in the aircraft.

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Reference Type: Conference Paper
Author: Hamann, S.; Waldraff, W.; Finsterwalder, R.
Year: 2004
Title: Development of a simulator audio system based on COTS sound synthesis software
Conference Name: AIAA Modeling and Simulation Technologies Conference and Exhibit

Conference Location: Providence, RI
Publisher: American Institute of Aeronautics and Astronautics (AIAA)
Date: August 16-19
Electronic Resource Number: AIAA 2004-5159
Author's Title and Affiliation: University of the Federal Armed Forces Munich, 85577 Neubiberg, Germany
Number of Pages: 10
Abstract: Early 2003 started the development of a simulator audio system as part of the project "MASTER" at the "University of the Federal Armed Forces Munich", Germany. The primary objective of this project is the realization of a modular vehicle simulator for educational and research purposes. In literature it has been shown, that there is a need for realistic communication simulations in aircrew training. Therefore, apart from the simulation of typical aircraft related noises, realistic communication simulation was taken as a requirement for the audio system development. Investigations have shown that only a few specialized software products for simulator audio systems are available on the market. A view beyond the simulator market indicates that all the required functionality it also covered by COTS sound sampling and synthesis software used in the music industry. The advantage of this market is that it has more users, which results in further developed software products and lower software prices. Based on a list of requirements, the COTS software "REAKTOR 4" from Native Instruments was selected to be the basis of the audio system development. With this software it is possible to set up large audio models by hierarchical block diagrams. Therefore, a variety of function blocks is provided by a block library. These functions include audio/control inputs and outputs, frequency and amplitude controlled samplers, oscillators, filters, shapers and mixers, as well as basic mathematical operators and event handling. In order to control the audio system application at a high control rate and with low latency the standardized OSC interface is used. Latency problems were avoided by using ASIO 2.0 standard for interfacing audio software and audio hardware. This enables the usage of COTS audio hardware. The described approach was used to realize a simulator audio system that meets all requirements for a professional training simulator.

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Reference Type: Report
Author: Hamilton, K.; Kantor, L.; Heslegrave, R.; Magee, L.; Hendy, K.
Year: 1989
Title: Simulator induced sickness in the CP-140 (Aurora) Flight Deck Simulator
City: Downsview, Ontario
Institution: Defence and Civil Institute of Environmental Medicine
Date: May
Type: Research Report
Report Number: DCIEM No 89-RR-32
Number of Pages: 20
Keywords: simulator sickness, ataxia, postural control, workload
Abstract: Training on modern flight simulators can lead to a condition referred to as simulator induced sickness (SIS) which is characterized by nausea, dizziness and postural instability. It is believed that SIS results from exposure to conflicting sensory information. The present report examined the incidence, severity and duration of SIS as a function of flight experience and aircrew position (pilot/copilot) in 16 aircrew following training on the CP-140 (Aurora) Flight Deck Simulator at Canadian Forces Base Greenwood. The dependent measures included symptomatology and postural stability. In addition, measures of workload were taken to examine the contribution of the high task demands generally associated with simulator training to the development of SIS symptomatology. The results indicated that over 50% of tested aircrew experienced increases in symptom frequency following simulator training with the most commonly reported symptoms being mild mental fatigue, physical fatigue, eye strain and after sensations of motion. This increase in symptom frequency was unaffected by either flight experience or aircrew position and symptoms dissipated, for the most part, after a few hours. No changes in postural stability were observed. The workload results confirmed that the simulator imposed high task demands on the aircrew. Furthermore, the workload results were consistent with the pattern of symptoms observed, suggesting that factors other than sensory conflict may be involved in the development of

symptomatology following simulator exposure. Future investigations should attempt to identify these factors so that SIS can be managed more effectively.

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Reference Type: Conference Proceedings
Author: Hamilton, Randy
Year of Conference: 2009
Title: Trainings to Avoid Deviations and Incursions
Conference Name: World Aviation Training Symposium
Conference Location: Orlando, FL
Notes: This was a PowerPoint presentation given at the WATS April 2009 Conference in Orlando.

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Reference Type: Conference Paper
Author: Hampton, Steve; Gibb, Gerald D.; Kirton, Tom; Phipps, John; Wise, John
Year: 1995
Title: An evaluation of reduced motion-based simulator use during initial training for MD-88 crews
Conference Name: The Eighth International Aviation Psychology Symposium
Conference Location: Columbus, OH
Date: April 24-27
Author's Title and Affiliation: Embry-Riddle Aeronautical University, Daytona Beach, FL 32114-3900
Number of Pages: 6
Keywords: MD-88, motion-based simulator
Abstract: To evaluate the training capabilities of a level 6 flight training device twenty-four pilots from Embry-Riddle were trained at Delta Airlines. Twelve of the pilots received the same flight training, except that the first five periods of training were flown in a level 6 flight training device with a visual system. No significant differences were noted in the performance of the pilots during a flight check conducted by APDs, and observed by independent check pilots from Embry-Riddle.
It is hoped that the results from the study will be used in part to justify further investigation into the capabilities of flight training devices, and whether or not they can be more effectively used during pilot training by both major, and regional airline operators. Because both the initial, and the operating costs of a full flight simulator are significantly higher than that of a flight training device, considerable savings may be possible to operators.

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Reference Type: Book Section
Author: Hancock, Peter; Sheridan, Tom
Title: The future of driving simulation
Editor: Fisher, Donald L.; Rizzo, Matthew; Caird, Jeff K.; Lee, John D.
Book Title: Handbook of driving simulation for engineering, medicine, and psychology
City: Boca Raton
Publisher: CRC press
Keywords: simulation, motion, driving
Abstract: Describes the need for motion simulation and a new augmented reality paradigm for driving simulation.
Notes: This is a draft of the chapter

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Reference Type: Journal Article
Author: Hanes, Douglas A.; McCollum, Gin
Year: 2006
Title: Cognitive-vestibular interactions: A review of patient difficulties and possible mechanisms

Journal: Journal of Vestibular Research
Volume: 16
Issue: 3
Pages: 75-91
Author's Title and Affiliation: Neuro-otology Department, Legacy Research Center, Portland, OR
Number of Pages: 18
Keywords: vestibular, cognitive, balance, spatial
Abstract: Cognitive deficits such as poor concentration and short-term memory loss are known by clinicians to occur frequently among patients with vestibular abnormalities. Although direct scientific study of such deficits has been limited, several types of investigations do lend weight to the existence of vestibular-cognitive effects. In this article we review a wide range of studies indicating a vestibular influence on the ability to perform certain cognitive functions. In addition to tests of vestibular patient abilities, these studies include dual-task studies of cognitive and balance functions, studies of vestibular contribution to spatial perception and memory, and works demonstrating a vestibular influence on oculomotor and motor coordination abilities that are involved in performance of everyday cognitive tasks. A growing literature on the physiology of the vestibular system has demonstrated the existence of projections from the vestibular nuclei to the cerebral cortex. The goals of this review are to both raise awareness of the cognitive effects of vestibular disease and to focus scientific attention on aspects of cognitive-vestibular interactions indicated by a wide range of results in the literature.
Author Address: Douglas A. Hanes, Neuro-otology Department, Legacy Research Center, 1225 NE 2nd Avenue, Portland, OR 97232, USA. Tel: +1 503 413 5348; E-mail: douglash@neurotology.org

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Reference Type: Journal Article
Author: Hanson, Terry
Year: 1998
Title: FOQA and ASAP
Journal: Safety Mind
Volume: 47
Pages: 5, 47-48
Number of Pages: 3

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Reference Type: Conference Proceedings
Author: Harper, Robert; Cooper, George
Year of Conference: 1984
Title: Wright Brothers Lectureship in Aeronautics - Handling qualities and pilot evaluation
Conference Name: AHS, ASEE, Aircraft Design Systems and Operations Meeting
Conference Location: San Diego, CA
Publisher: American Institute of Aeronautics and Astronautics (AIAA)
Date: October 31 - November 2
Electronic Resource Number: AIAA-1984-2442
Author's Title and Affiliation: Harper: Arvin/Calspan, Buffalo, NY
Cooper: G.E. Cooper Associates, Saratoga, CA
Abstract: [Introduction] The handling qualities of airplanes have been a subject of considerable interest and concern throughout the history of piloted flight. The Wright Brothers were successful in achieving the first powered flight in large measure because they provided adequate flying qualities for the task at hand. As they became capable of flights of longer duration, they altered the handling qualities of their flying machine to improve piloting performance and to accomplish the expanded tasks. They maintained, throughout, a balance between the amount of stability (or instability) of their airplane in flight and the pilot's ability to control its movements; they achieved a balance among the airplane's stability, the airplane's controllability, and the pilot's capability.
"Handling qualities" represent the integrated value of those and other factors and are defined as "those qualities or characteristics of an aircraft that govern the ease and precision with which a pilot is able to

perform the tasks required in support of an aircraft role." From this definition, it is clear that handling quality is characteristic of the combined performance of the pilot and the vehicle acting together as a system in support of an aircraft role. As our industry has matured in the past 82 years since the first powered flight, the performance, size, and range of application of the airplane have grown by leaps and bounds. Only the human pilot has remained relatively constant in the system.

In the beginning, the challenge was to find the vehicle which when combined with the inexperienced pilot-candidate, could become airborne, fly in a straight line, and land safely. Longer flights required turns, and ultimately there were additional tasks to be performed. As greater performance capability was achieved, the airplane was flown over increasingly greater ranges of altitude and speed, and the diversity of tasks increased. The continuing challenge was--and still is--to determine what characteristics an airplane should have so that its role can be achieved in the hands of a relatively constant pilot.

This challenge has been difficult to answer; the problem is that the quality of handling is intimately linked to the dynamic response characteristics of the airplane and human pilot acting together to perform a task. Since the pilot is difficult to describe analytically with accuracy, we have had to resort to experiments in order to experience the real system dynamics.

A further problem is in the evaluation process, the judging of differences in handling qualities. One would expect to instrument the aircraft, measure the accuracy of task performance, and separate good from bad in that way. The human pilot, however, is adaptive to different airplanes; he compensates as best he can by altering his control usage for differences among airplanes as necessary to accomplish the task. This compensatory capability makes task performance relatively insensitive to differences among airplanes, but at the same time, heightens the pilot's awareness of the differences by altering the total workload required to achieve the desired task performance.

The airplane designer, then, is presented with a formidable task. He must design an airplane to be of good dynamic quality when operated by an adaptive controller who resists analytic description. Experience--if carefully documented and tracked--is helpful, but the rapidly changing technology of flight (and the nomadic nature of the industry engineers) causes at least some part of each new aircraft development to break ground.

It is the purpose of this paper to examine this subject of handling qualities, defining first the dynamic system and discussing its constituent elements. Next, some historical perspective is introduced to illustrate that the quest for good handling has continued to be a challenge of substantial proportions from the Wright Brothers' beginning to the present day. The most modern methods of evaluating handling qualities place heavy emphasis on simulation and evaluation through experiment. The techniques, practice, and consideradons [sic] in the use of pilot evaluation are reviewed; recommendations are made which the authors believe would improve the quality of the evaluation data and the understanding of the pilot-vehicle system.

URL: http://www.aeromech.usyd.edu.au/RCplane%20USYD/Documentation/HCooper.pdf

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Reference Type: Journal Article
Author: Harris, L. R.; Jenkin, M.; Zikovitz, D.; Redlick, F.; Jaekl, P.; Jasiobedzka, U.; Jenkin, H.; Allison, R. S.
Year: 2002
Title: Simulating self motion I: Cues for the perception of motion
Journal: Virtual Reality
Volume: 6
Pages: 75-85
Type of Article: Draft version? from 12/15/01
Author's Title and Affiliation: Center for Vision Research
York University, 4700 Keele St., Toronto, Ontario, Canada M3J 1P3:
L.R. Harris: Departments of Psychology and Biology
M. Jenkin, U. Jasiobedzka, and R.S. Allison: Department of Computer Science
D. Zikovitz and F. Redlick: Department of Biology
P. Jaekl and H. Jenkin: Department of Psychology
Number of Pages: 11

Abstract: When people move there are many visual and non-visual cues that can inform them about their movement. Simulating self motion in a virtual-reality environment thus needs to take these non-visual cues into account in addition to the normal high-quality visual display. Here we examine the contribution of visual and non-visual cues to our perception of self-motion. The perceived distance of self motion can be estimated from the visual flow field, physical forces or the act of moving. On its own, passive visual motion is a very effective cue to self motion, and evokes a perception of self motion that is related to the actual motion in a way that varies with acceleration. Passive physical motion turns out to be a particularly potent self motion cue: not only does it evoke an exaggerated sensation of motion, but it also tends to dominate other cues.
URL: http://www.cse.yorku.ca/percept/papers/Harris-Simulating_Self-Motion_I.pdf
Author Address: Michael Jenkin: jenkin@cs.yorku.ca

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Reference Type: Report
Author: Harris, Randall L.; Bonadies, Gregory A.; Comstock, J. Raymond, Jr.
Year: 1990
Title: Usefulness of heart measures in flight simulation
City: Hampton, VA
Institution: NASA Langley Research Center
Document Number: 19900016226
Report Number: N90-25542
Number of Pages: 359
Accession Number: 90N25542
Keywords: flight simulation, heart, heart rate, variability, workloads (psychophysiology), aircraft guidance, aircraft landing, arousal, boredom, detection, diurnal variations, sensitivity, sympathetic nervous system
Abstract: The results of three studies performed at the NASA Langley Research Center are presented to indicate the areas in which heart measures are useful for detecting differences in the workload state of subjects. Tasks that involve the arousal of the sympathetic nervous system, such as landing approaches, were excellent candidates for the use of the average heart-rate and/or the increase in heart-rate during a task. The latter of these two measures was the better parameter because it removed the effects of diurnal variations in heart-rate and some of the intersubject variability. Tasks which differ in the amount of mental resources required are excellent candidates for heart-rate variability measures. Heart-rate variability measures based upon power spectral density techniques were responsive to the changing task demands of landing approach tasks, approach guidance options, and 2 versus 30 second interstimulus-intervals of a monitoring task. Heart-rate variability measures were especially sensitive to time-on-task when the task was characterized by minimal novelty, complexity, and uncertainty (i.e., heart-rate variability increases as a function of the subjects "boredom").
URL:
http://ntrs.nasa.gov/search.jsp?R=257380&id=2&as=false&or=false&qs=Ntt%3DHarris%252c%2BRandall%26Ntk%3DAuthorList%26Ntx%3Dmode%2Bmatchall%26Ns%3DHarvestDate%257c1%26N%3D0

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Reference Type: Report
Author: Hart, Daniel C.; Mitchell, David G.
Year: 1996
Title: A simulation investigation of motion cueing and visual time delay effects on two helicopter tasks
City: Moffett Field, CA
Institution: National Aeronautics and Space Administration (NASA)
Date: April
Type: NASA Technical Memorandum
Report Number: 110385
Author's Title and Affiliation: Hart: Aeroflightdynamics Directorate, U.S. Army Aviation and Troop Command
Mitchell: Hoh Aeronautics Inc., Lomita California

Number of Pages: 76
Keywords: simulation, simulation fidelity, visual delay, motion cueing, helicopter, handling qualities, simulator validation
Abstract: A piloted simulation study was performed on the NASA Ames Research Center's Vertical Motion Simulator to investigate motion and visual cueing fidelity for helicopter handling qualities research. A stability derivative mathematical model represented the helicopter dynamics. The piloting tasks were a precision hover and a sidestep. The first objective was to define a rationale for configuring the motion high-pass filters to yield the most realistic results for handling qualities experiments. Two principal quantities were varied: (1) the gain between the math model acceleration and commanded motion acceleration, and (2) the high-pass filter natural frequency motion configuration in the sidestep task over a high gain/high natural frequency motion configuration. The second objective was to investigate the effects of reducing the visual time delay. Compensation of the visual delays was preferred in a majority of the hover cases, but no consensus resulted in the sidestep task.

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Reference Type: Book Section
Author: Hart, Sandra G.; Staveland, Lowell E.
Year: 1988
Title: Development of NASA-TLX (Task Load Index): Results of empirical and theoretical research
Editor: Hancock, P.; Meshkati, N.
Book Title: Human Mental Workload
City: North Holland B.V.
Pages: 139-183
ISBN: 0-444-70388-8
Author's Title and Affiliation: Hart: Aerospace Human Factors Research Division, NASA-Ames Research Center, Moffett Field, CA
Staveland: San Jose State University, San Jose, CA
Number of Pages: 45
Abstract: The results of a multi-year research program to identify the factors associated with variations in subjective workload within and between different types of tasks are reviewed. Subjective evaluations of 10 workload-related factors were obtained from 16 different experiments. The experimental tasks included simple cognitive and manual control tasks, complex laboratory and supervisory control tasks, and aircraft simulation. Task-, behavior-, and subject-related correlates of subjective workload experiences varied as a function of difficulty manipulations within experiments, different sources of workload between experiments, and individual differences in workload definitions. A multi-dimensional rating scale is proposed in which information about the magnitude and sources of six workload-related factors are combined to derive a sensitive and reliable estimate of workload.

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Reference Type: Report
Author: Hass, Michael W.
Year: 1995
Title: The influence of stroboscopic auditory stimuli on visual apparent motion perception
City: Wright-Patterson Air Force Base, OH
Institution: Armstrong Laboratory (United States Air Force)
Date: November
Report Number: AL/CF-TR-1995-0142
Author's Title and Affiliation: Crew Systems Directorate, Human Engineering Division, 2255 H Street, Wright-Patterson AFB, OH 45433-7022
Keywords: visual perception, auditory perception, intersensory perception, manual operation, control attention
Abstract: The influence of moving auditory stimuli on visual apparent motion perception was empirically investigated. The experiments investigated perceptual organization of visual stimuli driven by inter-stimulus interval (ISI) and angular extent in the presence of moving and non-moving auditory stimuli.

Characteristics of, and refinements to, a new model of visual-auditory apparent motion perception are described. Dynamic characteristics of an auditory localizer, which was used in a large portion of this work, were evaluated to assess the ability to generalize the experimental results to others conditions. Influence characteristics of contemporaneous moving auditory stimuli on angular-extent-driven and ISA-driven visual perceptions were found to be cognitive in nature, small in magnitude, susceptible to perceptual hysteresis, and existed only when the visual-based perception was ambiguous. The small auditory influence over visual apparent motion perception was found to affect performance of a complex task, that task being tracking of an intermittent visual-auditory target, relative to tracking of an intermittent visual-only target. The auditory influence was affected by characteristics of the target movements and caused a reduction in the power spectral density of correlated and non-correlated tracking error between 0.1Hz and 0.5Hz.
URL: http://stinet.dtic.mil/oai/oai?&verb=getRecord&metadataPrefix=html&identifier=ADA327724
Access Date: August 16, 2007

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Reference Type: Journal Article
Author: Hayes, M. J. D.; Langlois, R. G.
Year: 2005
Title: Atlas: A novel kinematic architecture for six DOF motion platforms
Journal: CSME Transactions, Special Edition
Volume: 29
Issue: 4
Pages: 701-709
Author's Title and Affiliation: Mechanical and Aerospace Engineering, Carleton University, Ottawa, Ontario K1S 5B6 Canada
Keywords: Atlas, motion platform, history
Abstract: Conventional training simulators commonly use the hexapod configuration to provide motion cues. While widely used, studies have shown that hexapods are incapable of producing the range of motion required to achieve *high fidelity* simulation required in many applications. This paper presents an overview of the Atlas platform: a novel six DOF motion platform architecture. Orienting is decoupled from positioning, and unlimited rotations are possible about every axis of the mechanism. The decoupling is accomplished by fixing a three DOF spherical orienting device, called the Atlas sphere, on a gantry with three linear axes. The key to the design is three omni-directional wheels in an equilateral arrangement, which impart angular motions to a sphere, thereby providing rotational actuation. The omni-wheels and their castor rollers provide virtually friction-free motion parallel to each omni-wheel rotation axis creating the possibility for unconstrained rotational motion. Since the Atlas sphere rests on these omni-wheels, there are no joints or levers constraining its motion, allowing full 360̊ motion about all axes. The motivation, architecture, and potential applications for this motion platform are described.
Notes: Brief section on the history of flight simulator motion.
URL: http://www.mae.carleton.ca/~jhayes/Papers/HayesLanglois_rev2.pdf

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Reference Type: Magazine Article
Author: Hearn, Geoff
Year: 2006
Title: Low-cost airline - High-cost pilots?
Magazine: Airfinance Journal
Pages: 46-47
Date: April
Number of Pages: 2
Keywords: pilot shortage, pilot training, finance
Abstract: Pilot shortage is restricting growth and hampering new entrants, particularly in the booming Indian market. Geoff Hearn looks at how the industry's training sector is trying to increase the supply of qualified flight crew.

Notes: On 9/30/09, the website is no longer accessible.
URL: http://www.mechtronix.ca/c/mech/sim/file_db/airfinancejournalapril20063.pdf

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Reference Type: Journal Article
Author: Hecht, David; Reiner, Miriam; Halevy, Gad
Year: 2006
Title: Multimodal virtual environments: Response times, attention, and presence
Journal: Presence
Volume: 15
Issue: 5
Pages: 515-523
Date: October
Author's Title and Affiliation: Hecht: Technion — Israel Institute of Technology, Department of Education in Technology and Science, Haifi, Israel; University of Haifi, Haifi, Israel
Reiner and Halevy: Technion — Israel Institute of Technology, Department of Education in Technology and Science, Haifa, Israel.
Abstract: Multimodal virtual environments (VE) succeed better than single-sensory technologies in creating a sense of presence. We hypothesize that the underlying cognitive mechanism is related to a faster mental processing of multimodal events. Comparing simple detection times of unimodal (auditory, visual, and haptic) events, with bimodal and trimodal combinations, we show that mental processing times are in the following order: unimodal > bimodal > trimodal. Given this processing-speed advantage, multimodal VE users start their cognitive process faster, thus, in a similar exposure time they can pay attention to more informative cues and subtle details in the environment and integrate them creatively. This richer, more complete and coherent experience may contribute to an enhanced sense of presence.
Author Address: davidh@tx.technion.ac.il

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Reference Type: Journal Article
Author: Hecht, H.
Year: 2006
Title: Film as dynamic event perception: Technological development forces realism to retreat
Date: 2006
Number of Pages: 28
Abstract: I entertain the thesis that a human need holds the key to understanding event perception in film. Bazin entertained that photographs freed western painting from its obsession with realism. I extend this position by claiming that it is a basic human need to always have *one* medium that stands for the quintessential way to pictorially render reality. Only the medium that produces the currently most realistic renditions will have to be obsessed with realism. When motion pictures replaced still photography as the superior medium, photographs were - in turn - freed from the burden of realism. Movies will only be caught in this role until a superior medium - maybe virtual reality environments - become mainstream. This chapter assesses the remaining differences between natural viewing and motion pictures from the point of view of dynamic event perception. It takes a closer look at the perceptual regularities that constitute natural events, and the extent to which the same regularities can be captured in film. It then explores the violations of these regularities that occur in motion pictures. Some of these violations, such as the camera position at the time of recording differing from the spectator's viewpoint, cannot be helped. Other violations, such as temporal cuts and jumps between scenes, could be avoided. This opens up the question why directors choose to violate some laws of natural viewing while they stay away from violating others. Among these self-imposed limitations that the director chooses for her or his work are spatio-temporal constraints and causality constraints. I argue that directors have violated almost every single spatio-temporal law that holds

for natural events. The causality of natural events, on the other hand, is rarely touched in film: Objects do not spontaneously assemble out of dust, things fall down rather than up, etc. Thus, as progressively as directors play with place, time, and viewpoint, they are extremely conservative when it comes to the causality of events. Even cartoons and science fiction movies only scratch the surface and violate but a few minor causal laws. Does the psychology of dynamic event perception forbid serious violation of event causality in film? Or do directors merely follow self-imposed constraints because they are using the medium whose function it is to depict reality?
URL: http://art-mind.org/review/IMG/pdf/Hecht_2005_Film-as-event-perception.pdf

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Reference Type: Report
Author: Heffley, Robert K.; Clement, Warren F.; Ringland, Robert F.; Jewell, Wayne F.; Jex, Henry R.; McRuer, Duane T.
Year: 1981
Title: Determination of motion and visual system requirements for flight training simulators
City: Fort Rucker, AL
Institution: Systems Technology, Inc.
Date: August
Type: Technical Report
Report Number: 546
Recipient's Title and Affiliation: Department of the Army
Keywords: training simulators, pilot training, transfer of training, flight training, flight simulation, training devices, simulation, simulator fidelity, army aircraft, army training, visual perception, motion perception
Abstract: Fidelity requirements for Army flight training simulators are explored using a manual control theory approach. The first step is to define "simulator fidelity" in operational terms which provide a basis for each of the subsequent steps. This definition is accompanied by a taxonomy of measurable fidelity parameters. The next step, also of a preparatory nature, is the analysis of Army flight training missions. It describes how specific flight tasks and piloting techniques can be cast in terms compatible with feedback control theory. Pilot modeling techniques are then discussed, first in terms of pilot control and then in terms of pilot perception. Next, armed with compatible descriptions of fidelity, the training context, and pilot behavior, a procedure is described for studying visual and motion stimuli. It is found, however, that there are serious gaps in the experimental data base; and this precludes the systematic execution of this procedure. Because of the lack of data, it is not possible to accomplish fully the original objectives and, therefore, a formal bookkeeping scheme is outlined to guide the investigation of fidelity requirements. Conclusions and recommendations are then drawn. As aids to the reader, an executive summary and glossary of terms are provided.

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Reference Type: Journal Article
Author: Hegeman, J.; Honegger, F.; Kupper, M.; Allum, J. H. J.
Year: 2005
Title: The balance control of bilateral peripheral vestibular loss subjects and its improvement with auditory prosthetic feedback
Journal: Journal of Vestibular Research
Volume: 15
Issue: 2
Pages: 109-117
Author's Title and Affiliation: Department of ORL, University Hospital, Basel, Switzerland
Number of Pages: 10
Keywords: balance control, bilateral vestibular loss, auditory biofeedback, trunk sway, artificial signals, sensory inputs
Abstract: *Objectives:* We investigated whether long-term bilateral loss subjects could combine auditory biofeedback of trunk sway with their remaining natural sensory inputs on balance to provide an improved

control of trunk sway. A successful integration of natural and artificial signals would provide a basis for a balance prosthesis.
Methods: Trunk sway of 6 bilateral peripheral vestibular loss subjects (BVL) was recorded using either angular position- or velocity-based auditory feedback or no feedback during stance and gait tasks. Roll and pitch trunk movements were recorded with angular transducers mounted just above the waist and feedback without a delay to 4 loudspeakers placed at the left, right, front and rear borders of the 5 m long by 4 m wide test environment. Two types of auditory feedback or no feedback were provided to the subjects in random order. In the feedback modes, sway greater than a preset angle (ca. 0.5 deg) or velocity (ca. 3 deg/s) thresholds caused a tone to be emitted from the speaker towards which the subject moved. The tone volume increased with increasing angle or angular velocity amplitude.
Results: For all stance tasks BVL subjects without auditory feedback had a significantly different balance control with respect to that of normal controls. BVL sway values eyes open on a normal surface were reduced with auditory feedback with the greatest reductions in the roll plane. Specifically for the task of standing on 1 leg eyes open with position-auditory- feedback, amplitudes of pitch and roll angles and angular velocities were indistinguishable from those of normal controls. Sway during stance tasks on foam with eyes closed showed no improvement with feedback, remaining greater than normal. For some gait tasks there was a decrease in trunk sway with velocity feedback.
Conclusion: These initial results indicate that subjects with vestibular loss could incorporate the auditory prosthetic sensory information into their balance commands, particularly in the roll plane if the balance task is performed with eyes open. Position information appears more useful than velocity information in reducing trunk sway during stance tasks. Future work will need to determine the effect of a training time on the improvement in balance control using such a prosthetic device and the ideal position and velocity auditory feedback combination.
Author Address: Allum, J. H. J., Department of Audiology and Neurootology, University Hospital Basel, CH-4031, Basel, Switzerland, jallum@uhbs.ch

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Reference Type: Journal Article
Author: Heinrich, Sven P.; Renkl, Anette E.H.; Bach, Michael
Year: 2005
Title: Pattern specificity of human visual motion processing
Journal: Vision Research
Volume: 45
Pages: 2137-2143
Author's Title and Affiliation: Elektrophysiologisches Labor, Univ.-Augenklinik Freiburg, Killianstr. 5, 79106 Freiburg, Germany
Keywords: motion processing, pattern, adaptation, cortex, human, VEP
Abstract: Visual motion processing is strongly susceptible to adaptation. A variety of patterns have been used as stimuli in previous studies. Three of these, namely random dots, barcode-like gratings, and sinusoidal gratings, were compared in the present study using motion-onset visual evoked potentials (VEPs). We assessed the effects of the adaptation pattern and the test pattern to which the VEP is recorded. Furthermore, we evaluated the interaction between both, i.e. whether differences between adaptation and test pattern affect the response. Isodirectional and antidirectional adaptation were used to differentiate between the actual motion adaptation and associated flicker adaptation. Motion adaptation was almost 2.5-fold stronger ($p < 0.01$) if the same rather than different pattern types were used for both adaptation and test. This implies that separate neural populations are involved, suggesting the presence of pattern-tuned motion mechanisms.

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Reference Type: Report
Author: Heintzman, Richard J.
Year: 1997
Title: Determination of force cueing requirements for tactical combat flight training devices
Institution: SIMTEC Inc.

Date: February
Report Number: ASC-TR-97-5001
Author's Title and Affiliation: SIMTEC, Inc., 10364 Battleview Parkway, Manassas, VA 20109-2338
Keywords: force cueing, motion simulation, g-seat, g-suit, flight simulation
Abstract: This report documents the study which covered many considerations relating to force cueing in a simulator, including its effect on pilot behavior and performance and how cues may relate to different flight tasks and the performance of force cueing devices. The study also included a review of the evolution of platform motion systems, other force cueing devices and past force cueing research. Finally, an attempt is made to define a procedure to objectively determine the need for force cueing and its value as part of a ground based combat flight training system.
URL: http://www.virtualsimulation.com/reports/a975001.pdf

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Reference Type: Report
Author: Heintzman, Richard J.; Middendorf, Matthew; Basinger, James D.
Year: 1999
Title: Development and validation of a method of evaluating the effectiveness of fighter aircraft simulation force cueing devices
Institution: SIMTEC Inc.
Middendorf Scientific Services Inc.
Date: May
Report Number: ASC-TR-2000-5001
Author's Title and Affiliation: Heintzman: SIMTEC Inc. 10364 Battleview Parkway, Manassas, VA 20109-2338
Middendorf: Middendorf Scientific Services Inc., 227 East Main Street, Medway, OH 45341
Basinger: ASC/YW
Keywords: Force cueing, motion simulation, g-seat, dynamic seat, g-suit, flight simulation
Abstract: The report describes the development of a method for conducting force cueing evaluations for fighter aircraft simulators. The report includes a description of a Trial Force-Eval that was conducted to validate the evaluation method. This method includes both procedures and criteria for evaluation the effectiveness of various force cueing devices, such as platform motion systems, dynamic seats, etc., for tactical mission simulation. The Trial Force-Eval included a dynamic seat, actuation of the pilot's anti-g suit and Combat Edge. Supporting the Trial Force-Eval was a simplified fighter cockpit with F-15C dynamics, a limited field-of-view rear projection screen display and an Evans and Sutherland 4530 Image Generator. The report includes the results of the Trial Force-Eval that indicates that the force cueing devices contributed to the improvement of pilots' control behavior, performance and subjective opinion of the force cueing devices.
URL: http://www.virtualsimulation.com/reports/a99xxxx.pdf

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Reference Type: Journal Article
Author: Helmreich, Robert L.; Merritt, Ashleigh C.; Wilhelm, John A.
Year: 1999
Title: The evolution of crew resource management training in commercial aviation
Journal: International Journal of Aviation Psychology (IJAP)
Volume: 9
Issue: 1
Pages: 19-32
Author's Title and Affiliation: The University of Texas at Austin, Department of Psychology, Aerospace Crew Research Project
Number of Pages: 14
Keywords: crew resource management training, commercial aviation, cockpit, error management approach

Abstract: In this study, we describe changes in the nature of Crew Resource Management (CRM) training in commercial aviation, including its shift from cockpit to crew resource management. Validation of the impact of CRM is discussed. Limitations of CRM, including lack of cross-cultural generality are considered. An overarching framework that stresses error management to increase acceptance of CRM concepts is presented. The error management approach defines behavioral strategies taught in CRM as error countermeasures that are employed to avoid error, to trap errors committed, and to mitigate the consequences of error.

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Reference Type: Conference Paper
Author: Henderson, S.; Donderi, D. C.
Year: 2005
Title: Peripheral motion contrast sensitivity and older drivers' detection failure accident risk
Conference Name: 3rd International Driving Symposium on Human Factors in Driver Assessment, Training and Vehicle Design
Author's Title and Affiliation: Steven Henderson: Transportation Safety Board of Canada, Hull, Quebec
Don C. Donderi: McGill University, Montreal, Quebec
Number of Pages: 8
Abstract: Eighteen older drivers (66 to 88 years old) and their passengers both reported on the drivers' performance using questionnaires that elicited responses related to attention and to speed and accuracy of object motion perception. The measure of reported perceptual loss was an equally weighted combination of standardized responses from the 17-item driver questionnaire and the 11-item passenger questionnaire. Peripheral stationary and drifting contrast sensitivity was determined for 0.4 cycles per degree sine wave gratings at fifteen degrees eccentricity. The temporal two-alternative forced choice staircase procedure consisted of randomly interleaved left and right visual field presentations.
The correlation between $\log_{10}$ motion contrast sensitivity and reported perceptual loss was -.63 ($p<.01$), between age and perceptual loss was .56 ($p<.05$), and between age and $\log_{10}$ motion contrast sensitivity was -.54 ($p<.05$). The partial correlation between $\log_{10}$ motion sensitivity and reported perceptual loss, independent of age, was -.47 ($p=.054$. We concluded that some age-related driving performance deficits are associated with reduced sensitivity in the visual periphery.
Peripheral motion contrast sensitivity was discussed in relation to "useful field of view" (UFOV) measures of visual function, and offered as a primary deficit of high risk drivers with Alzheimer's disease.
This research was conducted at McGill University in partial fulfillment of the doctoral thesis requirement of the first author. Please note also that road safety is outside the mandate of the Transportation Safety Board of Canada.
URL: http://ppc.uiowa.edu/driving-assessment/2005/final/papers/07_SteveHendersonformat.pdf

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Reference Type: Conference Paper
Author: Hendy, K. C.
Year: 1995
Title: Situation awareness and workload: Birds of a feather?
Conference Name: Situation Awareness: Limitations and Enhancements in the Aviation Environment
Conference Location: Brussels, Belgium
Publisher: Advisory Group for Aerospace Research and Development (AGARD)
Date: April 24-28
Author's Title and Affiliation: Defence and Civil Institute of Environmental Medicine, PO Box 2000, North York, Ontario, Canada
Number of Pages: 7
Keywords: situation awareness, workload, situation awareness metric, performance, internal representation, mental model, perceptual control theory, measurement of workload, cognitive compatibility
Abstract: In this paper it is argued that an hierarchical information processing model, with a basis in perceptual control theory, provides the necessary framework for interpreting a large, unfocused empirical

literature on the topics of workload and situation(al) awareness (SA). The fundamental importance of situation awareness will emerge in considering the role of the mental model in providing the reference signal for a closed loop perceptual control system. It will be asserted that those aspects of the mental model generally covered by the SA rubric result from high level information processing activity that requires spare capacity to service. Increasing time pressure (workload) reduced the capacity available for this activity. An experiment in the application of a workload scale (NASA TLX) and a situation awareness metric (SART) to a simulated air traffic control environment is cited. It will be shown that the situation awareness scale taps largely into the workload side of the equation rather than the SA side. Implications for the measurement of SA will be drawn.

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Reference Type: Journal Article
Author: Hess, Ronald A.
Year: 1977
Title: Prediction of pilot opinion ratings using an optimal pilot model
Journal: Human Factors
Volume: 19
Issue: 5
Pages: 459-475
Date: October
Author's Title and Affiliation: NASA Ames Research Center, Moffett Field, CA
Number of Pages: 17
Abstract: A brief review of some of the more pertinent applications of analytical pilot models to the prediction of aircraft handling qualities is undertaken. The relative ease with which multiloop piloting tasks can be modeled via the optimal control formulation makes the use of optimal pilot models particularly attractive for handling qualities research. To this end, a rating hypothesis is introduced which relates the numerical pilot opinion rating assigned to a particular vehicle and task to the numerical value of the index of performance resulting from an optimal pilot modeling procedure as applied to that vehicle and task. This hypothesis is tested using data from piloted simulation and is shown to be reasonable. An example concerning a helicopter landing approach is introduced to outline the predictive capability of the rating hypothesis in multiaxis piloting tasks.

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Reference Type: Journal Article
Author: Hess, Ronald A.
Year: 1989
Title: Theory for aircraft handling qualities based upon a structural pilot model
Journal: Journal of Guidance, Control, And Dynamics
Volume: 12
Issue: 6
Pages: 792-797
Date: November
Author's Title and Affiliation: University of California, Davis
Number of Pages: 6
Abstract: A theory for describing the manner in which aircraft dynamic characteristics determine pilot opinion ratings of aircraft handling qualities is discussed. The theory centers upon the role of pilot rate feedback in continuous tracking. A structural model of the human pilot is used to quantify the amount of rate feedback the pilot is required to use in the control of an aircraft in a specific task. Using the model, 35 vehicle configurations that have been evaluated in manned simulation are analyzed. The tasks range from simple single axis, single-loop pitch attitude tracking to precision hover and landing approach, in which control of both vehicle position and attitude are required. The manner in which control system sensitivity affect pilot opinion rating is also investigated. The rate feedback theory is supported by the results of the model-based analyses, where it is shown that the mean square value of the rate feedback signal in the model correlates with the pilot opinion ratings obtained from experiment.

Reference Type: Journal Article
Author: Hess, Ronald A.
Year: 1990
Title: Model for human use of motion cues in vehicular control
Journal: Journal of Guidance, Control, And Dynamics
Volume: 13
Issue: 3
Pages: 476-482
Date: May
Author's Title and Affiliation: University of California, Davis
Number of Pages: 7
Abstract: A feedback model for human use of motion cues in tracking and regulation tasks is offered. The motion cue model is developed as a single extension of a structural model of the human pilot, although other equivalent dynamic representations of the pilot could be used in place of the structural model. In the structural model, it is hypothesized that proprioceptive cues and an internal representation of the vehicle dynamics allow the human to create compensation characteristics that are appropriate for the dynamics of the particular vehicle being controlled. It is shown that an additional loop closure involving motion feedback can improve pilot/vehicle dynamics by decreasing high-frequency phase lags in the effective open-loop system transfer function. Data from a roll-attitude tracking/regulation task conducted on a moving base simulator are used to verify the modeling approach.

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Reference Type: Journal Article
Author: Hess, R. A.
Year: 1995
Title: Modeling the effects of display quality upon human pilot dynamics and perceived vehicle handling qualities
Journal: IEEE Transactions on Systems, Man, and Cybernetics
Volume: 25
Issue: 2
Pages: 338-344
Date: February
Number of Pages: 7
Keywords: display quality, human pilot dynamics, perceived vehicle handling qualities, closed loop systems, visual scene quality, minimum separable acuity, VCR, visual cue ratio, closed loop tracking with degraded displays, model parameters
Abstract: A model-based technique addressing the effect of display or visual scene quality upon human pilot dynamics is introduced. The technique builds upon a methodology proposed for the preliminary assessment of flight simulator fidelity which uses a structural model of the human pilot. This model is incorporated in what is termed the primary control loop(s) for the task at hand. It is shown that the measured effects of degradations in display quality upon human pilot dynamics can be modeled by simple reductions in the gains associated with error and proprioceptive signals in the structural model. A control theoretic rationale for these gain reductions is presented. The effect of display quality upon perceived handling qualities is discussed and demonstrated in a simple example. Although the research had its genesis in flight simulator fidelity studies, the modeling procedure is applicable to any continuous control task involving degraded visual conditions.

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Reference Type: Journal Article
Author: Hess, R. A.
Year: 1997
Title: Unified theory for aircraft handling qualities and adverse aircraft-pilot coupling
Journal: Journal of Guidance, Control, And Dynamics
Volume: 20

Issue: 6
Pages: 1141-1148
Date: November
Author's Title and Affiliation: University of California, Davis
Number of Pages: 8
Abstract: A unified theory for aircraft handling qualities and adverse aircraft-pilot coupling or pilot-induced oscillations is introduced. The theory is based on a structural model of the human pilot. A methodology is presented for the prediction of 1) handling qualities levels, 2) pilot-induced oscillation rating levels, and 3) a frequency range in which pilot-induced oscillations are likely to occur. Although the dynamics of the force-feel system of the cockpit inceptor is included, the methodology will not account for effects attributable to control sensitivity and is limited to single-axis tasks and, at present, to linear vehicle models. The theory is derived from the feedback topology of the structural model and an examination of flight test results for 32 aircraft configurations simulated by the U.S. Air Force/CALSPAN NT-33A and Total In-Flight Simulator variable stability aircraft. An extension to nonlinear vehicle dynamics such as that encountered with actuator saturation is discussed.

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Reference Type: Book Section
Author: Hess, R. A.
Year: 2002
Title: Aircraft dynamics and control
Editor: Webster, J.
Book Title: Wiley Encyclopedia of Electrical and Electronics Engineering
Publisher: John Wiley and Sons, Inc.
Pages: 1-29
Number of Pages: 30
Abstract: *Aircraft dynamics* refers to the equations that describe how an aircraft responds to the forces and moments that act upon it. *Aircraft control* refers to the availability to move an aircraft along a desired trajectory in three-dimensional space at some desired speed. The subject is approached here in three parts. First, the equations that describe the motion of a rigid aircraft in a moving (nonquiescent) air mass are presented and discussed. Second, the applicability of these equations is demonstrated, and the topic of control synthesis is introduced through a simple control design example. The example requires only control synthesis techniques covered in a typical undergraduate engineering course on the subject and represents what has been termed a *classical* approach to aircraft control. Implementation of the resulting control system on a digital computer is discussed, and a simulation of the flight control system is presented. Third, *modern* control design approaches are discussed that involve control synthesis techniques more advanced than that of the design example. Pertinent concepts and definitions are introduced throughout.

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Reference Type: Book Section
Author: Hess, Ronald A.
Year: 2002
Title: Pilot control
Editor: Tsang, Pamela S.; Vidulich, Michael A.
Book Title: Principles and Practice of Aviation Psychology
City: Mahwah, NJ
Publisher: Erlbaum
Chapter: 8
Author's Title and Affiliation: University of California

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Reference Type: Journal Article
Author: Hess, R. A.; Malsbury, T.; Atencio, A. Jr.
Year: 1993
Title: Flight simulator fidelity assessment in a rotorcraft lateral translation maneuver
Journal: Journal of Guidance, Control, and Dynamics
Volume: 16
Issue: 1
Pages: 79-85
Date: January-February
Author's Title and Affiliation: Hess and Malsbury: University of California
Atencio: NASA Ames Research Center
Number of Pages: 7
Abstract: A model-based methodology for assessing flight simulator fidelity in closed-loop fashion is exercised in analyzing a rotorcraft low-altitude maneuver for which flight test and simulation results were available. The addition of a handling qualities sensitivity function to a previously developed model-based assessment criteria allows an analytical comparison of both performance and handling qualities between simulation and flight test. Model predictions regarding the existence of simulator fidelity problems are corroborated by experiment. The modeling approach is used to assess analytically the effects of modifying simulator characteristics on simulator fidelity.

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Reference Type: Journal Article
Author: Hess, R. A.; Siwakosit, W.
Year: 2001
Title: Assessment of flight simulator fidelity in multiaxis tasks including visual cue quality
Journal: Journal of Aircraft
Volume: 38
Issue: 4
Pages: 607-614
Date: July-August
Author's Title and Affiliation: University of California, Davis
Number of Pages: 8
Abstract: A technique for analytical assessment of flight simulator fidelity is presented as an extension of a methodology previously introduced in the literature. The assessment is based on a computer simulation of the pilot and vehicle and is inherently task dependent. A simple model of visual cue quality is introduced that is based on the classical concept of human operator visual remnant. The complete assessment procedure now includes proprioceptive, vestibular, and visual cue modeling. Inverse dynamic analysis is employed that allows the use of compensatory models of the human pilot in multiaxis tasks. The methodology is exercised by considering a simple rotorcraft lateral and vertical repositioning task in which visual and motion cue quality is varied.

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Reference Type: Book Section
Author: Hettinger, L. J.
Year: 2002
Title: Illusory self-motion in virtual environments
Editor: Stanney, K. M.
Book Title: Handbook of Virtual Environments
City: Mahwah, NJ
Publisher: Lawrence Erlbaum
Pages: 471-491
Chapter: 23
Author's Title and Affiliation: Logicon Technical Services, Inc. 57 Myrick Lane, Harvard, MA 01451
Author Address: lhettinger@logicon.com

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Reference Type: Web Page
Author: Heusmann, Jim
Year: 1995
Title: Glossary of modeling and simulation (M&S) terms
Publisher: Department of Defense, United States of America
Access Year: 2007
Access Date: Feb. 5
Last Update Date: August 29, 1995
Type of Medium: Draft
Author's Title and Affiliation: DMSO POC
Number of Pages: 82
URL: http://home.earthlink.net/~gwhite2/glossary.html

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Reference Type: Newspaper Article
Reporter: Hill-Holtzman, Nancy
Year: 1992
Title: Hey, pay attention! Zoning out can be hazardous to your health, safety expert says
Newspaper: Los Angeles Times
City: Santa Monica
Frequency: Daily
Pages: 1-3
Section: Westside; PART-J; Zones Desk
Issue Date: September 20
URL: http://articles.latimes.com/1992-09-20/news/we-1767_1_safety-expert/3

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Reference Type: Electronic Article
Author: Hinson, David R.
Year: 1996
Title: Draft B-737 recommendations
Recipient's Title and Affiliation: Federal Aviation Administration, Washington, DC 20591
National Transportation Safety Board
Notes: From the October 15, 1995 Public Meeting on B-737 Safety Recommendations

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Reference Type: Conference Paper
Author: Hodgkinson, J.; Rossitto, K. F.; Kendall, E. R.
Year: 1991
Title: The use and effectiveness of piloted simulation in transport aircraft research and development
Conference Name: Flight Mechanics Panel Symposium on Flight Simulation Effectiveness
Conference Location: Brussels, Belgium
Publisher: Advisory Group for Aerospace Research and Development (AGARD)
Date: October 14
Author's Title and Affiliation: Douglas Aircraft Company, 3855 Lakewood Boulevard, Long Beach, CA 90846
Number of Pages: 8
Keywords: transport aircraft, motion
Abstract: Simulation requirements for military and for commercial transport aircraft are contrasted. The special problems introduced by active control are discussed with reference to earlier fighter data. Transport simulator experiments to explore these problems are described.
Notes: Published in February 1992

Reference Type: Report
Author: Hoh, Roger H.; Baillie, Stewart W.; Morgan, J. M.
Year: 1987
Title: Flight investigation of the tradeoffs between augmentation and displays for NOE flight in low visibility
City: Cherry Hill, NJ
Institution: American Helicopter Society
Date: October 13
Report Number: 414
Author's Title and Affiliation: Hoh: Systems Technology, Inc., Hawthorne, CA
Baillie, Morgan: National Aeronautical Establishment, Ottawa, Ontario, Canada
Number of Pages: 15
Keywords: NOE flight, visual cues, nap-of-the-earth, field of view, Cooper-Harper ratings
Abstract: The missions proposed for the next generation helicopter involve requirements to operate in essentially zero visibility in the nap-of-the-earth (NOE) environment. Such operations will require the use of pilot vision aids, which gives rise to the question of the interaction of such displays and the required aircraft handling qualities. This research was conducted to: 1) investigate the required visual cueing for low speed and hover, and 2) determine if an increase in stabilization can effectively be used to compensate for the loss of essential cues. Two flight test experiments were conducted using a conventional helicopter, and a variable stability helicopter, as well as electronically fogged lenses and night vision goggles with daylight training filters. The primary conclusion regarding the essential cues for hover was that fine-grained texture (microtexture) was more important than large discrete objects (macrotexture) or field of view. The use of attitude was a way to make up for display deficiencies. However, a corresponding loss of agility occurred with the tested attitude command/attitude hold system resulting in unfavorable pilot comments. Hence, the favorable control display tradeoff must be interpreted in the context that the best solution would be to improve the vision aid. Such an improvement would require an increase in the visible microtexture, an advancement in display technology which is unlikely to be available in the foreseeable future. Therefore, a criterion was developed to systematically evaluate display quality and the associated upgrade in required stabilization as a function of increasingly degraded visual cues.
Notes: National Specialists' Meeting on Flight Controls and Avionics.

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Reference Type: Report
Author: Holt, Robert W.; Boehm-Davis, Deborah A.; Ikomi, Philip A.; Hansberger, Jeffrey T.; Beaubien, J. Matthew; Incalcaterra, Kara A.; Seamster, Thomas L.; Hamman, William; Schultz, Kim
Year: 1998
Title: CRM procedures and crew performance--Executive summary of advanced crew resource management (ACRM) evaluation
Author's Title and Affiliation: Holt, Boehm-Davis, Ikomi, Hansberger, Beaubien, Incalcaterra: George Mason University
Seamster: Cognitive & Human Factors
Hamman: Captain, United Airlines
Schultz: Captain, Atlantic Coast Airlines
Number of Pages: 12
Keywords: CRM procedures, crew performance
Abstract: A three-year research effort to determine the effectiveness of a proceduralized Crew Resource Management system (ACRM). George Mason University worked with a regional and a major carrier in determining that this approach to CRM does enhance crew performance and, by inference, increases safe operations.

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Reference Type: Journal Article
Author: Hopkins, Charles O.
Year: 1975
Title: How much should you pay for that box?
Journal: Human Factors
Volume: 17
Issue: 6
Pages: 533-541
Author's Title and Affiliation: University of Illinois at Urbana-Champaign
Keywords: cost, motion systems
Abstract: Some claimed cost, safety, efficiency, and effectiveness advantages of aircraft simulators for training are equivocal. Effectiveness of simulator training depends mostly upon the training procedures. Other factors alleged to influence the effectiveness of simulators vary in their demonstrated importance. These are considered in the contexts of physical simulation vs. psychological simulation, simulator fidelity and motivation, and pilot acceptance. One of the more costly areas of engineering development to increase fidelity of physical simulation is motion systems. No experimental evidence is available to show that simulator motion enhances transfer of training. Cost effectiveness has not been demonstrated for many interesting and attractive features that are standard trimmings on flight training simulators. The acquisition of simulators costing several times as much to own and operate as their counterpart airplanes may produce a backlash that will set back the desirable use of cost-effective simulators in reasonable research and training programs.

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Reference Type: Journal Article
Author: Horattas, C. G.
Year: 1981
Title: Gravitational-cueing system: An enhancement of aircraft flight simulation
Journal: Transportation Research Record: Air Service, Airport Access, and Future Technology
ISSN: 803
Number of Pages: 5
Keywords: gravitational-cueing system, aircraft flight simulation
Abstract: This paper describes a man-machine interface that is used in aircraft trainers to create artificial acceleration cues, which are perceived by the pilot as the cues produced by real environmental effects. This interface, designated as the gravitational cueing (g-cueing) system, translates acceleration components generated in an aerodynamic math model into cues that creates sensations experienced in a real aircraft. The g-cueing system is a microprocessor controlled, hydraulically and pneumatically actuated, stand-alone system that can enhance the realism of the simulated flight environment.

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Reference Type: Conference Paper
Author: Hosman, Ruud
Year: 1999
Title: Are criteria for motion cueing and time delays possible?
Conference Name: AIAA Modeling and Simulation Technologies Conference and Exhibit
Conference Location: Portland, OR
Publisher: American Institute of Aeronautics and Astronautics (AIAA)
Date: August 9-11
Electronic Resource Number: AIAA-1999-4028
Author's Title and Affiliation: Director, Aerospace Man-Machine Systems Consulting, Wielengahof 46, 2625 LK Delft, The Netherlands
Number of Pages: 10
Abstract: In spite of a continuing development of flight simulation over the past thirty years, there are still some areas where flight simulation is not a one to one replacement of real flight and can not completely fulfill the reasonable and objective requirements. To fulfill these needs, the proper feedback of effective

motion cues seem [sic] to encounter two significant shortcomings, resulting from a lack of full understanding of (a) the impact of motion cueing on the pilot's behavior and (b) the requirements for motion cueing in the specific training application.
During the past twenty years, research projects on pilot motion perception and manual control have been performed in the Netherlands at the Delft University of Technology, the National Aerospace Laboratory, NLR, and the TNO Institute for Human Factors. The results have not only improved the knowledge on pilot's aircraft motion perception and control, but also initiated a reconsideration of motion feedback in flight simulation. Full flight simulation is meant to integrate the pilot's skill-based, rule-based and knowledge-based behavior in his control of the total aircraft system. Distinguishing the contribution of motion feedback to these three levels of behavior provides the tool to discriminate the impact of motion feedback on these levels of the resulting pilot behavior. Based on this discrimination, a review of motion system requirements, and washout filter design and optimization, subject to the training goal, becomes possible. The paper reviews the major results of the motion perception research, explains the discrimination of motion cues based on the three levels of behavior, and shows the impact on motion-base drive algorithm design. The significance of simulation-induced delays on compensatory manual control is shown, underscoring the value of such research in objectively defining future simulator requirements.

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Reference Type: Conference Paper
Author: Hosman, Ruud; Advani, Sunjoo; Haeck, Nils
Year: 2002
Title: Integrated design of flight simulator motion cueing systems
Conference Name: Developments in Simulator Systems - Integration and Effectiveness
Conference Location: London
Publisher: Royal Aeronautical Society (RAeS)
Date: May 8-9
Author's Title and Affiliation: Ruud Hosman: Director, Aerospace Man-Machine Systems Consulting, Deft, The Netherlands
Sunjoo Advani: Director, Simulation & Training, Aircraft development & Systems Engineering B.V., Hoofdorp, The Netherlands
Nils Haeck: Mathematics and Motion Control Specialist, Hellevoetsluis, The Netherlands
Number of Pages: 12
Abstract: A forward design process applicable to the specification of flight simulator cueing systems is presented in this paper. This process is based on the analysis of the pilot-vehicle control loop by using a pilot model incorporating both visual and vestibular feedback, and the aircraft dynamics. After substituting the model for the simulated aircraft, the analysis tools are used to adjust the washout filter parameters with the goal of restoring pilot control behavior. This process allows the specification of the motion cueing algorithm. Then, based on flight files representative for the operational flight envelope, the required motion system space is determined. The motion-base geometry is established based on practical limitations as well as criteria for the stability of the platform with respected to singular conditions. With this process the characteristics of the aircraft, the tasks to be simulated, and the missions themselves are taken into account in defining the simulator motion cueing system.
URL: http://www.simdesign.nl/pubs/integrated_design_of_flight_simulator_motion_cueing_system.pdf

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Reference Type: Conference Proceedings
Author: Hosman, Ruud; Grant, Peter R.; Schroeder, Jeffery A.
Year of Conference: 2005
Title: Pre and post pilot model analysis compared to experimental simulator results
Conference Name: AIAA Modeling and Simulation Technologies Conference and Exhibit
Conference Location: San Francisco, CA
Publisher: American Institute of Aeronautics and Astronautics (AIAA)
Date: August 15-18

Electronic Resource Number: AIAA 2005-6303
Author's Title and Affiliation: Hosman: Director, AMS Consult
Grant: Assistant Professor, Aerospace Engineering, University of Toronto
Schroeder: Chief (Acting), Aviation Systems Division, NASA Ames Research Center
Number of Pages: 13
Abstract: In 2003, a workshop on the use of pilot models to analyze the influence of visual and vestibular motion perception on a pilot's control behavior was held. As an example, an earlier experiment on the Vertical Motion Simulator (VMS) at NASA Ames was used to demonstrate that a pilot model analysis could reasonably explain the trends of the experimental results. More importantly, the same analysis suggested an experimental configuration that, if tested, might have changed the general conclusions found in the NASA Ames study.
Useful progress in research is enhanced when new studies and analyses build upon previous studies and analyses. A new simulator experiment built upon the NASA Ames study and also evaluated all the new conditions analyzed with the pilot model during the workshop noted above. The results roughly correspond with the analysis. Although the utmost was done to produce the same motion cues in the University of Toronto research flight simulator as in the VMS experiment before, differences in the experimental results were found between the results of the NASA experiment and the University of Toronto experiment. The paper reviews the initial analysis, compares the analysis results with the new results from the new experiment, and readjusts the pilot model analysis with the new results.
Author Address: Hosman: AMS Consult, Dijkgraafstraat 26, 2645 KN Delfgauw, The Netherlands; r.hosman@amsconsult.demon.nl
Grant: University of Toronto, 4925 Dufferin Street, Toronto, Ontario, M3H 5T6, Canada
Schroeder: Aviation Systems Division, NASA Ames Research Center, Moffett Field, CA 94035

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Reference Type: Conference Paper
Author: Hosman, Ruud; Hammon, Bill; Lehman, Chris; Pelchat, Yvan; Schroeder, Jeff
Year: 2001
Title: Summary of the panel discussion on motion cueing requirements
Conference Name: AIAA Modeling and Simulation Technologies Conference and Exhibit
Conference Location: Montreal, Quebec
Publisher: American Institute of Aeronautics and Astronautics (AIAA)
Date: August 6-9
Electronic Resource Number: AIAA-2001-4253
Author's Title and Affiliation: Hosman - AMS Consult
Hamman - United Airlines
Lehman - Civil Aviation Training Magazine
Pelchat - CAE Electronics Ltd.
Schroeder - NASA Ames Research Center
Number of Pages: 9
Abstract: During the 2000 AIAA Modeling and Simulation Technologies Conference a panel discussion on motion cueing requirements was held. Representatives from the airline industry, the simulator manufacturers, and the research community introduced the discussion topic by expressing their point of view. The audience of around 40 attendees actively took part in the discussion. When talking about motion cueing criteria the main question is not if motion cueing is necessary for simulation. Although motion cueing is required for full flight simulators, this question was still an open question during the panel discussion. Looking back at the session, the more fundamental questions when and why motion feedback is necessary were not raised and answered directly. The aim of pilot training is to assure proficiency, and proficiency is more than the manual skill to handle the aircraft. To what extent motion contributes to a pilot's training and his proficiency is more complex than long has been understood. Motion contributes to a pilot's control behavior and his visual-vestibular perception of the aircraft's motion. The aircraft's handling characteristics, the particular maneuvers and pilot's skill-based manual control behavior determine if the motion feedback is essential in simulator training. The requirements for full simulators primarily ask for physical characteristics of the motion system and a subjective judgment of the motion cues. Both the manufacturers and the research community ask for more decisive requirements for motion

cueing in the future. A more integrated approach to the requirements for the motion system and the motion cueing algorithms, both in relation to the simulation objective, seem more effective. The paper reviews the introductions and the discussion. Although the approach from the airline industry, the simulator manufacturers, and the research community representatives were quite different, the summary of the session gives a broad view of what the different disciplines and the audience considered important.

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Reference Type: Conference Paper
Author: Hosman, Ruud; Schuring, Jan; van der Geest, Peter
Year: 2005
Title: Pilot model development for the manual balked landing maneuvre
Conference Name: AIAA Modeling and Simulation Technologies Conference
Conference Location: San Francisco, California
Publisher: American Institure of Aeronautics and Astronautics
Number of Pages: 13
Abstract: Based on the need to set up requirements for the obstacle free zone for the New Large Aircraft, and renew the Collision Risk Model, the Instrument Flight Procedural Panel (IFPP) of the ICAO asked for the development of pilot models capable to simulate pilot's skill-based control behavior of a manual flown approach to land followed by a balked landing. The pilot model was developed to control the B-747-400 based on a dedicated aircraft model developed by the Boeing Company. The FAA will use the combined pilot-aircraft model as the basis for a Monte Carlo Simulation to determine the aircraft deviations from the nominal flight path under a wide range of atmospheric and operational conditions. The IFPP asked for two pilot models based on different principles. The present model is based on control engineering principles. In the course of the development of both pilot models it turned out that a procedural model was required to model and control pilot's rule-based behavior initiating the discrete procedural actions. Since the first publication of McRuer on models of pilot's control behavior a wide range of models describing human control behavior have been developed. The present model is based on an extension of McRuers work, has visual and vestibular feedback and is describing pilot's control behavior in the inner attitude control loop. For the present application, sub models to describe pilot's behavior in the outer loops were developed. In addition, special attention had to be paid to the pilot model to obtain accurate lateral control of the aircraft during the de-crab. Special attention had to be paid to the non-linear part of pilot's control behavior necessary to match pilot model tracking performance. The pilot model is build up into three groups of models for symmetric, asymmetric and longitudinal control for the different phases of the total maneuver: Flight Director segment, visual segment, flare and de-crab, go-around and re-crab and Flight Director climb out. Thrust control is applied only for the FD and visual segment. The pilot model parameters are adjusted for each phase with criteria for tracking performance, control effort and control bandwidth and stability. To match the results of the pilot model with measured pilot performance use is made of the results of a Balked Landing Simulator Experiment performed at NASA Ames. The paper will describe the pilot model, the interaction with the procedural model, the tracking performance results and the comparison with the experimental results of the NASA Ames simulator study.

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Reference Type: Book
Author: Hosman, Ruud J. A. W.
Year: 1996
Title: Pilot's perception and control of aircraft motions
City: Delft, The Netherlands
Publisher: Delft University Press
ISBN: ISBN: 90-407-1384-7
NUGI: 841
Author's Title and Affiliation: Delft University of Technology
Keywords: motion perception, simulation, control behavior

Reference Type: Conference Paper
Author: Hosman, Ruud J. A. W.; Mulder, Max; Theunissen, Erik
Year: 1995
Title: Perception of flight information from EFIS displays
Conference Name: IFAC Symposium on Analysis, Design and Evaluation of Man-Machine Systems
Conference Location: Massachusetts Institute of Technology, Cambridge, MA
Author's Title and Affiliation: Delft University of Technology, Faculty of Aerospace Engineering, P.O. Box 5058, 2600GB Delft, The Netherlands
Theunissen: Delft University of Technology, Faculty of Electrical Engineering, P.O. Box 5031, 2600 GA Delft, The Netherlands
Number of Pages: 6
Keywords: displays, man/machine interface, human factors, cognitive systems
Abstract: Pilot's perception of variables presented on the Electronic Flight Instrument System, EFIS, has been investigated. A stimulus response technique has been used to determine the accuracy and speed of the perception process. By varying the exposure time of the stimuli, it has been shown that the perception of the variable magnitude is faster and more accurate than the perception of the first derivative or rate of that variable. Results of experiments on roll and pitch attitude perception, the influence of scale division, and the perception of the indicated airspeed are shown.

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Reference Type: Conference Paper
Author: Hosman, R. J. A. W.; Roggekamp, R. P. G. M.; Van der Vaart, J. C.
Year: 1988
Title: Contribution of vestibular system output to motion perception
Conference Name: Twenty-Third Annual Conference on Manual Control
Conference Location: Massachusetts Institute of Technology, Cambridge, MA
Author's Title and Affiliation: Delft University of Technology, Faculty of Aerospace Engineering
Number of Pages: 20
Abstract: The influence of motion cues on pilot's control behavior in actual and simulated flight has been studied for many years. Results of these studies show that under certain conditions addition of cockpit motion improves pilot's tracking performance.
At the Faculty of Aerospace Engineering of the Delft University of Technology pilot's perception of the aircraft motion from visual and vestibular motion cues has been investigated in more detail. The results of an experiment using a second order system step response as a roll input to the subjects showed a much faster subject response when presented to the subject using simulator cockpit motion compared to the presentation of the stimulus on the artificial horizon.
To analyze the background of this faster response a more detailed analysis of the influence of the vestibular system dynamics on its output compared to the stimulus was necessary. In the literature the vestibular system output due to input angular acceleration is normally related to input angular rate. Such a comparison showed that the vestibular output also leads the stimulus roll rate which seemed to confirm the experimental findings. It turned out that the lead time of the vestibular output relative to the angular rate is strongly dependent on the bandwidth of the input stimulus. With decreasing stimulus bandwidth the lead of the vestibular output increases.
A stimulus response experiment was performed using a second order step response as input signal. Three values of the own frequency ω_0 (0.65, 1 and 2 rad/sec) of the second order system were used. The difference in subject's response time due to the vestibular and visual stimulation increased as was expected with decreasing own frequency ω_0 of the stimulus generating second order system. It is concluded that the vestibular system decreases the time needed to perceive the aircraft motion by 150 msec or more which has a beneficial effect on pilot's performance and control behavior.

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Reference Type: Conference Paper
Author: Hosman, Ruud J. A. W.; Van der Steen, Han F. A. M.
Year: 1993
Title: False cue detection thresholds in flight simulation
Conference Name: AIAA Flight Simulation Technologies Conference
Conference Location: Monterey, CA
Publisher: American Institute of Aeronautics and Astronautics (AIAA)
Date: August 9-11
Electronic Resource Number: AIAA-93-3578-CP
Author's Title and Affiliation: Delft University of Technology, Faculty of Aerospace Engineering, Delft, The Netherlands
Number of Pages: 9
Abstract: In this paper a new experimental method is presented for the design of motion filters, based on simple concepts using a multi sensory perception model.
We will present the results of recent research on the perception thresholds for differences in the visual and vestibular cues as determined by using a sled as well as a research flight simulator for linear motions (surge and heave). These differences will be called *false cues.* Peripheral visual cues are modulated relative to the vestibular cues to determine the threshold values. The thresholds turn out to be dependent on velocity magnitude. The no-motion ranges turn out to be so large that they are useful in simulation.

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Reference Type: Report
Author: Hosman, R. J. A. W.; Van der Vaart, J. C.
Year: 1978
Title: Vestibular models and threshold of motion perception: Results of a test in a flight simulator
City: Delft, The Netherlands
Institution: Department of Aerospace Engineering, Delft University
Report Number: LR-265

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Reference Type: Conference Paper
Author: Hosman, R. J. A. W.; Van der Vaart, J. C.
Year: 1981
Title: Effects of vestibular and visual motion perception on control task performance
Conference Name: First Annual Conference on Manual Control and Decision-Making
Conference Location: Delft, The Netherlands
Author's Title and Affiliation: Delft University of Technology, Department of Aerospace Engineering
Number of Pages: 27
Keywords: compensatory tracking tasks, visual motion, vestibular motion
Abstract: The influence of visual and vestibular motion perception on pilot's behavior in a control task has aroused many discussions during the last decades which have not yet come to an end. This influence is of direct relevance to the modeling of pilot control behavior and to flight simulation.
Results of experiments in this field as reported in the literature appeared to be somewhat different from the experience gained in the research flight simulator of the Department of Aerospace Engineering of the Delft University of Technology. The aim of the experiment described in the present paper was to obtain a data base on pilot's behavior using central and peripheral visual and motion cues.
In a following task (or compensatory tracking task) and in a disturbance task (both roll tasks) using a double integrator as the controlled element, all possible combinations of central visual, peripheral visual and vestibular motion cues were presented to the subjects.
The results show significant influence of the peripheral visual and vestibular cues on subject's performance and dynamic behavior in both control tasks.
Notes: Same as Acta Psychologica article from same year.

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Reference Type: Journal Article
Author: Hosman, R. J. A. W.; Van der Vaart, J. C.
Year: 1981
Title: Effects of vestibular and visual motion perception on task performance
Journal: Acta Psychologica
Issue: 48
Pages: 271-287
Author's Title and Affiliation: Delft University of Technology, The Netherlands
Number of Pages: 17
Keywords: vestibular, visual motion perception, task performance, motion base simulator
Abstract: The effects of foveal and peripheral visual as well as vestibular cues on performance and control behavior of subjects in two different roll control tasks were studied in a moving base flight simulator with low noise motion characteristics.
Two different roll control tasks were used, one being a following task (or compensatory tracking task) where a displayed random signal was to be tracked, the other being a disturbance task in which a random signal perturbed the controlled system and the roll angle was kept at zero.
Consistent improvement in controller performance was found after adding visual peripheral or vestibular (motion) cues to the basic configuration consisting of a central CRT display. Control behavior, as expressed by controller transfer functions, was also markedly influenced by the addition of these extra motion cues, the changes in control behavior being dependent on the types of control task. Some possible causes for this dependence are also discussed.

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Reference Type: Conference Paper
Author: Hosman, R. J. A. W.; Van der Vaart, J. C.
Year: 1982
Title: Accuracy of visually perceived roll angle and roll rate using an artificial horizon and peripheral displays
Conference Name: Second European Conference on Manual Control and Decision-Making
Conference Location: Bonn
Date: June 2-4
Author's Title and Affiliation: Delft University of Technology, Department of Aerospace Engineering, Kluyverweg 1, 2629 HS, Delft, The Netherlands
Number of Pages: 18
Abstract: In a series of computer-controlled tests, subjects were required to make accurate and fast estimates of roll attitude or roll rate presented at short intervals on a central CRT-display (artificial horizon). The influence of exposure time and, in the case of the roll rate perception task the influence of the presence of displays in the peripheral field of vision, were investigated.
It appeared that roll attitude perception is more accurate and can be accomplished at much shorter exposure times than roll rate perception. Moreover the reaction time for roll attitude perception is about 0.1 sec shorter than for roll rate perception using the central display. Peripheral displays showed to improve roll rate perception and to decrease reaction time.

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Reference Type: Conference Paper
Author: Hosman, R. J. A. W.; Van der Vaart, J. C.
Year: 1983
Title: Perception of roll rate from an artificial horizon and peripheral displays
Conference Name: Nineteenth Annual Conference on Manual Control
Conference Location: Massachusetts Institute of Technology, Cambridge, MA
Date: May 23-25
Author's Title and Affiliation: Delft University of Technology, Department of Aerospace Engineering
Number of Pages: 23

Abstract: It was shown earlier that peripheral side displays can help to improve the performance of subjects in tracking tasks. The work reported in the present report was undertaken to find out whether this improvement was due to an increase in 'arousal level', a more accurate or a faster perception of roll rate.
The experiment described investigates the perception accuracy of roll rate by subjects from a central CRT-display (simulated artificial horizon), peripheral side displays (moving checkerboard pattern) and both displays combined. Discrete values of roll rate were presented to the subjects during exposure times between 0.1 and 0.8 second.
Immediately after stimulus exposure the displays were either plainly blanked or masked by a dithering line on the central display or dithering of the checkerboard pattern on the peripheral displays.
Results show that the roll rate perception process from peripheral displays is more accurate and up to 0.1 second faster than from the central display. Masking shows to have a different influence on the central visual perception than on the peripheral visual perception.

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Reference Type: Conference Paper
Author: Hosman, R. J. A. W.; Van der Vaart, J. C.
Year: 1984
Title: Accuracy of system step response roll magnitude estimation from central and peripheral visual displays and simulator cockpit motion
Conference Name: Conference on Manual Control
Conference Location: NASA Ames Research Center, Moffett Field, CA
Date: June 12-14
Author's Title and Affiliation: Delft University of Technology, Department of Aerospace Engineering, Kluyverweg 1 - 2629 HS, Delft, The Netherlands
Number of Pages: 15
Abstract: The present experiment is an extension of work done in previous years, at Delft University, on the accuracy and temporal properties of visual roll attitude and roll rate perception.
In earlier perception tasks, discrete stimuli of roll attitude were presented on a central artificial horizon type display. Roll rate rests were done with the same display and with peripheral visual field displays showing moving checkerboard patterns.
From tracking tasks in a flight simulator it was found that cockpit motion improved tracking accuracy and the present experiment was designed to assess the improvements of perception due to cockpit motion.
As it is not possible to present and to manipulate discrete motion stimuli in a moving cockpit just as in the case of visual stimuli alone, a different setup had to be chosen in which dynamic system step responses of roll angle were the stimuli to be presented.
After the onset of the motion, subjects were to make accurate and quick estimates of the final magnitude of the roll angle step response by pressing the appropriate button of a keyboard device. The differing time-histories of roll angle, roll rate and roll acceleration caused by a step response will stimulate the different perception processes related the central visual field, peripheral visual field and vestibular organs in different, yet exactly known ways.
Experiments with either of the visual displays or cockpit motion and some combinations of these were run to assess the roles of the different perception processes.
Results show that the differences in response time are much more pronounced than the differences in perception accuracy.

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Reference Type: Conference Proceedings
Author: Hosman, R. J. A. W.; Van der Vaart, J. C.
Year of Conference: 1988
Title: Visual-vestibular interaction in pilot's perception of aircraft or simulator motion
Conference Name: AIAA Flight Simulation Technologies Conference
Conference Location: Atlanta, GA
Publisher: American Institute of Aeronautics and Astronautics (AIAA)

Date: September 7-9
Electronic Resource Number: AIAA Paper 88-4622-CP
Author's Title and Affiliation: Delft University of Technology, Faculty of Aerospace Engineering, Delft, The Netherlands
Number of Pages: 11
Abstract: The importance of man's vestibular organs in perceiving cockpit motion in an aircraft or a simulator is nowadays hardly questioned, as witnessed by the present widespread use of six-degrees-of-freedom motion systems for flight simulators. Still more advantage could be gained from the use of moving base simulators.
In order to illustrate this, the paper reviews research on control behavior and performance of subjects in target following and disturbance tasks. By using results of work by authors and others, the importance of peripheral visual and vestibular motion perception in tasks that require inner-loop stabilization, is emphasized. Results of stimulus response experiments, especially designed to gather insight in central and peripheral visual and vestibular perception of motion are summarized and used to explain findings of tracking experiments.
It is concluded that peripheral visual and cockpit motion cues are of paramount importance in actual or simulated manual aircraft control and that, in simulation, the compensation for simulator motion system dynamics, computing time-delays and motion control laws deserve much more attention.

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Reference Type: Book Section
Author: Hosman, R. J. A. W.; Van der Vaart, J. C.
Year: 1989
Title: Visual-vestibular interaction in pilot's perception of aircraft or simulator motion
Editor: Baarspul, M.; Mulder, J. A.
Book Title: Essays in Stability and Control
City: Delft, The Netherlands
Publisher: Delft University of Technology
Abstract: The importance of man’s vestibular organs in perceiving cockpit motion in an aircraft or a simulator is nowadays hardly questioned, as witnessed by the present widespread use of six-degrees-of-freedom motion systems for flight simulators. Still more advantage could be gained from the use of moving base simulators.
In order to illustrate this, the paper reviews research on control behavior and performance of subjects in target following and disturbance tasks. By using results of work by the authors and by others, the importance of peripheral visual and vestibular motion perception in tasks that require inner loop stabilization, is emphasized. Results of stimulus response visual and vestibular perception of motion are summarized and used to explain findings of tracking experiments.
It is concluded that peripheral visual and cockpit motion cues are of paramount importance in actual or simulated manual aircraft control and that, in simulation, the compensation for simulator motion system dynamics, computing time-delays and motion control lows deserve much more attention.

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Reference Type: Book Section
Author: Howard, I. P.
Year: 1986
Title: The perception of posture, self motion, and the visual vertical
Editor: Boff, K.; Kaufman, L.; Thomas, J.
Book Title: Handbook of Perception and Human Performance: Sensory Processes and Perception
City: New York
Publisher: John Wiley and Sons
Volume: 1
Pages: 18-27
Edition: 1
Original Publication: Human Spatial Orientation

Reference Type: Book Section
Author: Howard, I. P.; Cheung, B.; Landolt, J.
Year: 1987
Title: Influence of vection axis and body posture on visually-induced self-rotation and tilt
Book Title: Aerospace Medical Panel Symposium on Motion Cues in Flight Simulation and Simulator Induced Sickness
City: Brussels, Belgium
Publisher: Advisory Group for Aerospace Research and Development (AGARD)
Pages: 15-1 - 15-8
ISBN: AGARD-CP-433
Author's Title and Affiliation: Howard, Cheung: York University, Institute for Space and Terrestrial Science, Human Performance Laboratory, North York, Ontario, Canada, M3J 1P3
Landolt: DCIEM, 1133 Sheppard Ave. North York, Ontario, Canada, M3M 3B9
Number of Pages: 8
Keywords: vection axis, motion cues, posture, visually induced tilt
Abstract: Yaw vection is induced by a scene rotating about the spinal axis (z axis), pitch vection by a scene rotating about an axis in the mid-frontal plane (y axis) and roll vection by a scene rotating about an axis parallel to the line of sight (x-axis). Each of these axes can be vertical or horizontal, making six conditions in all, of which only four have been studied previously. We studied vection and illusory body tilt under all six conditions, with a full rotating field, reduced somesthetic cues and in a situation in which body rotation could occur. Yaw vection around a vertical axis was strongest. Forward pitch vection was stronger than backward pitch vection. Contrary to previous reports, for most subjects backward illusory tilt was much stronger than forward illusory tilt. Two subjects experienced 360° body rotation in the horizontal-pitch condition. The direction of pitch axis asymmetry was found to be consistent and not related to the asymmetry of vertical optokinetic nystagmus.
URL: http://stinet.dtic.mil/oai/oai?verb=getRecord&metadataPrefix=html&identifier=ADA202492

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Reference Type: Conference Paper
Author: Howard, I. P.; Ohmi, M.; Simpson, W.; Landolt, J. P.
Year: 1987
Title: Vection and the spatial disposition of competing moving displays
Conference Name: Aerospace Medical Panel Symposium on Motion Cues in Flight Simulation and Simulator Induced Sickness
Conference Location: Brussels, Belgium
Publisher: Advisory Group for Aerospace Research and Development (AGARD)
Date: September 29
Author's Title and Affiliation: Howard, Ohmi, Simpson: York University, Institute of Space and Terrestrial Science, Human Performance Laboratory, North York, Ontario, Canada, M3J 1P3
Landolt: DCIEM, 1133 Sheppard Ave. North York, Ontario, Canada, M3M 3B9
Number of Pages: 8
Keywords: vection, moving displays, visual displays
Abstract: In Experiment 1, we investigated the relative effectiveness of two superimposed displays in generating circularvection as a function of (i) the separation in depth between them, (ii) their perceived relative differences, and (iii) which display was in the plane of focus. Circularvection was found to be governed by the display that was perceived more distant even when it was actually nearer. Vection was not affected by whether the near or far display was in the plane of focus, nor by which display was fixated or pursued by the eyes. In Experiment 2, we asked whether the generally held belief that vection is induced most effectively by peripheral stimuli is due to an artifactual effect of perceived distance. The experiment assessed the separate contributions of foreground-background and central-peripheral placement of competing displays. It was found that both factors contribute in an interactive way to the experience of vection. In Experiment 3, we investigated how linear forward vection induced by looming visual display is affected by the near-far relationships of competing displays.
URL: http://stinet.dtic.mil/oai/oai?verb=getRecord&metadataPrefix=html&identifier=ADA202492

Reference Type: Conference Proceedings
Author: Howard-Jones, Tom
Year of Conference: 2003
Title: The current status and application of ATC training simulators
Conference Name: Simulation of the Environment
Conference Location: London, UK
Publisher: Royal Aeronautical Society (RAeS)
Pages: 1-13
Number of Pages: 13
Abstract: ATC simulators are used for all levels and types of controller training for both civil and military operations. Current progress is evolutionary using advances in PC products with innovative simulation software and services.
Much greater use could be made of simulators for validation and conversion training. Budgets for air traffic control training and simulators are low.
Links between air traffic control and flight simulators have been demonstrated. The benefits of providing an ATC environment for the pilot are recognised. Given the commercial demand the technology for the solutions can be delivered.
The creation of synthetic pilots for air traffic control training, by using voice recognition and voice output wiht automation is an important commercial goal. Voice recognition is currently viable for basic training particularly where correct pronunciation and phraseology is to be reinforced. It can also help with more advanced work if used carefully.
Advances in PC image generators and visualisation software are promising to make 3D tower simulation more accessible. Problems remain over subjective acceptance especially for meeting the real world measures for aircraft detection recognition and identification. By the wider use of binocular functions and zoom capabilities sensible training objectives can be met with affordable systems.
Work is underway to try and introduce standards for ATC simulators.
Successful users are those who can clearly identify the training requirements and the media performance necessary to meet them. They are also able to appreciate the physical limitations of the current technology that they can afford to employ.

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Reference Type: Conference Paper
Author: Howells, P.B.; Siksik, D.N.
Year: 2000
Title: Applications and future trends in synthetic environments for military training systems
Conference Name: Flight Simulation - The Next Decade
Conference Location: London, UK
Publisher: Royal Aeronautical Society (RAeS)
Date: May 10-12
Author's Title and Affiliation: CAE Electronics, Ltd., St-Laurent, Quebec, Canada
Number of Pages: 8
Abstract: This paper gives details of the new generation of simulators that have been built. These simulators use Synthetic Environments to increase training capacity. In recent years, the trend has shifted markedly from the synthetic environment that merely provided a threat lay down to a synthetic environment that provides support for collaborative training. In this new role, the synthetic environment complements training through computer generated entities that maneuver and behave as manned counterparts. The example systems presented in this paper cover a broad spectrum of applications that encompass air, land and sea domains.

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Reference Type: Journal Article
Author: Huang, J. K.; Young, L. R.
Year: 1987
Title: Influence of visual and motion cues on manual lateral stabilization
Journal: Aviation, Space, and Environmental Medicine (ASEM)
Volume: 58
Issue: 12
Pages: 1197-1204
Date: December
Author's Title and Affiliation: Huang: Old Dominion University, Department of Mechanical Engineering and Mechanics, Norfolk, VA
Young: Massachusetts Institute of Technology, Man Vehicle Laboratory, Cambridge, MA
Number of Pages: 8
Keywords: visual and motion cues, manual lateral stabilization, visual influence
Abstract: The ability of humans to detect and control their own lateral acceleration was measured by means of a closed-loop nulling task. Wide-field moving visual cues enhanced the operator's performance in nulling self-motion, especially at lower frequencies. Even visual cues, fixed relative to the operator, resulted in performance improvement relative to self-motion nulling in the dark. Describing function (frequency response) data was obtained for random acceleration conditions consisting of the visual field fixed relative to the laboratory, fixed relative to the subject, and in the dark. The describing function data was corrected for the dynamics of operator manual control strategy. The resulting frequency responses were used to develop a linear model of self-motion detection which required a lead term of 1.5 $rad \cdot s^{-1}$ to be added to the existing model in order to match the higher sensitivity at higher frequencies.

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Reference Type: Journal Article
Author: Hubbard, Todd P.
Year: 2006
Title: What we should know about human error: A review of ten questions about human error
Journal: International Journal of Applied Aviation Studies
Volume: 6
Issue: 2
Pages: 339-341
Type of Article: Book Review
Number of Pages: 3
Abstract: A review of the book *What We Should Know About Human Error: A Review of Ten Questions about Human Error* by Sidney Dekker

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Reference Type: Journal Article
Author: Huddleston, H. F.; Rolfe, J. S.
Year: 1971
Title: Behavioral factors influencing the use of flight simulators for training
Journal: Applied Ergonomics
Volume: 2
Issue: 3
Pages: 141-148
Number of Pages: 8
Abstract: The case for using flight simulators as a training aid is propounded, and the drawbacks of training entirely in flight are listed. Transfer of learning from the simulated to real-life situation is discussed with relevant examples. A diagram illustrating the relative cost of using different types of simulator is given, and recent research is discussed. Finally, the attitude and influence of the organization to simulator, trainee and instructor is described.

Reference Type: Journal Article
Author: Huet, Michael; Jacobs, David M.; Camachon, Cyril; Goulon, Cedric; Montagne, Gilles
Year: 2009
Title: Self-controlled concurrent feedback facilitates the learning of the final approach phase in a fixed-base flight simulator
Journal: Human Factors: The Journal of the Human Factors and Ergonomics Society
Volume: 51
Issue: 6
Pages: 858-871
Date: December
Electronic Resource Number: 10.1177/0018720809357343
Number of Pages: 14
Abstract: This study (a) compares the effectiveness of different types of feedback for novices who learn to land a virtual aircraft in a fixed-base flight simulator and (b) analyzes the informational variables that learners come to use after practice.
Background: An extensive body of research exists concerning the informational variables that allow successful landing. In contrast, few studies have examined how the attention of pilots can be directed toward these sources of information.
Method: In this study, 15 participants were asked to land a virtual Cessna 172 on 245 trials while trying to follow the glide-slope area as accurately as possible. Three groups of participants practiced under different feedback conditions: with self-controlled concurrent feedback (the self-controlled group), with imposed concurrent feedback (the yoked group), or without concurrent feedback (the control group).
Results: The self-controlled group outperformed the yoked group, which in turn outperformed the control group. Removing or manipulating specific sources of information during transfer tests had different effects for different individuals. However, removing the cockpit from the visual scene had a detrimental effect on the performance of the majority of the participants.
Conclusion: Self-controlled concurrent feedback helps learners to more quickly attune to the informational variables that allow them to control the aircraft during the approach phase. *Applications:* Knowledge concerning feedback schedules can be used for the design of optimal practice methods for student pilots, and knowledge about the informational variables used by expert performers has implications for the design of cockpits and runways that facilitate the detection of these variables.

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Reference Type: Magazine Article
Author: Hughes, D.
Year: 1999
Title: Airbus training center uses advanced techniques
Magazine: Aviation Week & Space Technology
Pages: 66-67
Date: July 26
Number of Pages: 2
Abstract: Airbus Industries continues to refine its automated cockpit training to take advantage of new technology and the latest crew resource management techniques.

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Reference Type: Magazine Article
Author: Hughes, D.
Year: 1999
Title: NASA glass cockpit study finds improved training
Magazine: Aviation Week & Space Technology
Pages: 63-65
Date: July 26
Number of Pages: 3

Abstract: A NASA study of Continental Airlines pilots' transition into glass cockpit aircraft show that training has been vastly improved for automated aircraft even though pilots continue to make programming and mode awareness errors in operating computer-driven systems.

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Reference Type: Magazine Article
Author: Hughes, David
Year: 2005
Title: Airbus shows interest in Honeywell's auto pull-up software
Magazine: Aviation Week
Date: September 25
Keywords: auto pull-up, automatic flight control, envelope protection, upset recovery training (URT)
Abstract: Airbus may one day offer its customers an option based on software being developed by Honeywell to take control of an aircraft and steer it away from terrain.
URL:
http://www.aviationweek.com/aw/generic/story_generic.jsp?channel=awst&id=news/09265p08.xml&headline=Airbus%20Shows%20Interest%20in%20Honeywell's%20Auto%20Pull-Up%20Software

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Reference Type: Conference Paper
Author: Human Factors and Ergonomics Society (HFES)
Year: 2006
Title: Proceedings of the Human Factors and Ergonomics Society 50th annual meeting
Conference Name: Human Factors and Ergonomics Society 50th Annual Meeting
Conference Location: San Francisco, CA
Publisher: Human Factors and Ergonomics Society
Date: October 16-20
Notes: See program for contents: http://www.hfes.org/web/HFESMeetings/2006AMprogram2.pdf

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Reference Type: Web Page
Author: Human Performance Center (HPC)
Year: 2002
Title: Cockpit and Crew Resource Management (CRM): Trends and Research
Access Year: 2007
Access Date: Feb. 5
Keywords: crew resource management training
Abstract: Crew Resource Management (CRM) training addresses the interactions of aviation team members and how those interactions affect the safety and effectiveness of the aircrew's mission.
Notes: Links include: Hardware and Software Issues; Benefits, Risks, Costs; Development Issues; Applications; WWW Related Sites; References
URL: http://spider.adlnet.gov/index.cfm?RID=TTE_OT_1000017

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Reference Type: Electronic Article
Author: Human Systems Information Analysis Center (Human Systems IAC)
Year: 2001
Title: Spatial disorientation
Periodical Title: Human Systems ICA Gateway
Volume: XII
Issue: 3
Pages: 1-16

Number of Pages: 16
Keywords: upset recovery training (URT), spatial disorientation
Abstract: Special Issue includes:
"Spatial Disorientation Research" - Introduction by Major Todd Heinle
Glossary of Spatial Disorientation Terms and Spatial Disorientation Acronyms
"Measuring the Head Tilt Illusion During Sustained Acceleration" by Tamara L. Chelette, Ph.D., P.E. (AFRL/HEPA)
"Canadian Approach to Spatial Disorientation Training" by Dr. Bob Cheung (Defence and Civil Institute of Environmental Medicine)
"Spatial Disorientation, Geographic Disorientation, Loss of Situation Awareness, and Controlled Flight into Terrain" by Bill Ercoline (Veridian Engineering) and Fred Previc (Northrup Grumman Information Technology)
"Advanced Display Technologies: What Have We Lost? by James W. Meehan (Defence Science and Technology Organization)
"Desdemona: Advanced Disorientation Trainer" by Dr. Willem Bles (TNO Human Factors)
URL: http://www.dtic.mil/dticasd/docs-gw/gw_xii_3.pdf

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Reference Type: Report
Author: Humlie, Matt; Naumann, Leroy; Goldsmith, Timothy E.; Johnson, Peter J.
Year: 1998
Title: Some statistical considerations in assessing pre-training maneuver evaluations
Pages: 1-5
Date: July 30
Author's Title and Affiliation: Humlie, Naumann: Delta Air Lines
Goldsmith, Johnson: University of New Mexico
Number of Pages: 5
Keywords: pre-training maneuver

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Reference Type: Journal Article
Author: Iacobucci, D.
Year: 2005
Title: From the editor: On p-values
Journal: Journal of Consumer Research
Volume: 32
Issue: 1
Date: June
Number of Pages: 11
Keywords: null hypothesis testing, statistics
Abstract: Periodically, social scientists debate the strengths ands weaknesses of hypothesis testing (for which researchers pose the question, e.g., "Are my group means the same or different?") compared with effects estimation (motivated by the question, "How large is the difference between my group means?"). As is often the case, the extreme positions are clear but they approach ideology, and a moderate stance seems the more constructive prescription.
The testing of null hypotheses affords researchers many advantages (Abelson 1997; Cortina and Dunlap 1997; Frick 1996; Greenwald et al. 1996; Hagen 1997; Harris 1997; Mulaik, Raju, and Harshman 1997). Of primary importance, the test of a null hypothesis is conducted in the context of a simple decision rule and provides a dichotomous outcome (Greenwald et al. 1996, 177). While critics would argue that hypothesis tests provide less information compared to alternative techniques, supporters argue that the binary decisions nevertheless enable scholarly progress and theory testing, which "requires nothing more than a binary decision about the relation between two variables" (Chow 1988, 105; Wainer 1999).

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Reference Type: Report
Author: IATA Flight Simulator Working Group
Year: 2002
Title: Simulated air and ground traffic environment for flight training
Date: June
Type: Revision 2

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Reference Type: Book
Author: International Air Transport Association (IATA)
Year: 1993
Title: Flight simulator design and performance data requirements
City: Montreal
Edition: 4th
ISBN: ISBN 92-9035-532-8
Keywords: configuration and design data, simulation modeling data, flight test validation and proof of match data aerodynamics and flight controls
Abstract: Lists all specific data types which must be tested and collected in flight simulation, covering aerodynamics, propulsion, ground handling, weight and moments of inertia, fuel, electrical power, ECS, hydraulics, instruments, sound and vibration.

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Reference Type: Report
Author: International Civil Aviation Organization (ICAO)
Year: 1995
Title: Manual of criteria for the qualification of flight simulators
Institution: International Civil Aviation Organization (ICAO)
Report Number: 9625-AN/938
Number of Pages: 53

Keywords: levels of simulator qualification, international test guide, types of evaluations, evaluators handbook
Abstract: This manual establishes performance and documentation requirements for the evaluation of airplane flight simulators used for training and checking of flight crew members. These test standards and methods of compliance were derived from extensive experience of regulatory authorities and industry. The manual is intended to provide the means for a State civil authority to qualify a flight simulator, subsequent to a request by an applicant, through initial and recurrent evaluations of the flight simulator. Further, the manual is intended to provide the means for the civil aviation authorities of other states to accept the qualifications granted by the state which conducted the initial and recurrent evaluation of the flight simulator, without repetitive reevaluations, when considering the approval of the use of that flight simulator from their own state.

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Reference Type: Web Page
Author: IRADIS
Year: 2006
Title: History [of flight training and simulation]
Last Update Date: September 20, 2006
Notes: Contents:
Early History
Instrument Flight Training
World War II
Electronic Flight Simulation
Digital Simulators
References
URL: http://www.iradis.org/education/history/early_history

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Reference Type: Journal Article
Author: Ito, Yatsuji; Gifo, Japan; Gresty, Michael A.
Year: 1997
Title: Subjective postural orientation and visual vertical during slow pitch tilt for the seated human subject
Journal: Aviation, Space, and Environmental Medicine
Volume: 68
Issue: 1
Pages: 3-12
ISSN: 0095-6562
Number of Pages: 10
Accession Number: 1997-02282-001
Keywords: postural orientation & visual estimates during pitch tilt, healthy vs labyrinthine defective adults
Abstract: Explored the relationship between the perception of postural orientation and of orientation of external visual object in pitch by evaluating estimates of subjective postural tilt with concurrent settings of the visual vertical during substantial magnitudes of pitch tilt. Normal Ss, aged within active service years of 16–50, were compared with 5 labyrinthine deficient Ss (LDSs), aged 29–60 yrs, to establish the relative importance of proprioceptive and labyrinthine signals for pitch orientation. Restrained and seated in darkness in a simulator, Ss estimated when they were tilted 0°, 45°, and 90° forwards and backwards during cycles of pitching at a constant velocity. Ss' estimates of postural tilt were consistently greater than machine tilt. Postural estimates became more accurate with repetition, but visual verticals deteriorated. LDSs performed similarly to normal Ss. Overestimations of tilt, particularly backwards, may be due to a shift in reference from the head to the trunk–leg axis.

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Reference Type: Journal Article
Author: Ivanenko, Yuri P.; Viaud-Delmon, I.; Sémont, A.; Gurfinkel, V. S.; Berthoz, A.
Year: 1999
Title: Eye movements during torso rotations in labyrinthine-defective subjects
Journal: Journal of Vestibular Research: Equilibrium & Orientation
Volume: 9
Issue: 6
Pages: 401-412
ISSN: 0957-4271
Number of Pages: 12
Accession Number: 2000-13180-001
Keywords: torso rotations with space stationary head vs head & shoulders, horizontal eye movements & perception of head vs head & shoulder rotation, 69-79 yr olds with complete vestibular loss
Abstract: Examined whether chronic loss of vestibular function modified perceptual and oculomotor responses during torso rotations in darkness. Ss (4 69–79 yr olds with complete vestibular loss and 7 healthy Ss) were seated on a rotating chair ((±30 degrees,.1 Hz and .011 Hz) in space stationary head (neck stimulation) or space stationary head and shoulders (torso stimulation) conditions. Eye movements and perception of head motion in space during neck stimulation were similar to those during torso stimulation for all Ss. During .011 Hz rotations all Ss perceived illusory head or head and shoulder rotation and shifted their gaze in the direction of illusory head rotation. There was no significant difference in eye movements between normal and labyrinthine-defective (LDF) Ss. During .1 Hz rotations, LDF Ss had significantly larger eye deviations and increases in the gain of the slow component of eye movements. In these conditions patients mostly perceived illusory head or head and shoulder rotation in space; normal Ss mainly perceived the head as stationary. The results show that neck and torso rotations can evoke similar ocular responses in LDF Ss and that chronic loss of vestibular function modifies the representation of axial body segment motion relative to space.

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Reference Type: Report
Author: Ivey, David J.; Poland, Kristin; Michaelis, Michael D.; Thompson, Lawrence E.; Jacob, Armand; Loo, Thierry; McCloy, Thomas M.; Haworth, Loran A.
Year: 2002
Title: Vertical Motion Simulator activities phase I: Backdrive of accident flight
Series Editor: Elias, Bartholomew (Group Chairman)
City: Washington, DC
Institution: National Transportation Safety Board (NTSB) Human Performance Group
Date: October 3
Number of Pages: 21
Keywords: American Airlines flight 587, upset recovery training (URT), Vertical Motion Simulator (VMS)

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Reference Type: Conference Proceedings
Author: Jackson, E. Bruce; Hildreth, Bruce L.; York, Brent W.; Cleveland, William B.
Year of Conference: 2004
Title: Evaluation of a candidate flight dynamics model simulation standard exchange format
Conference Name: AIAA Modeling and Simulation Technologies Conference and Exhibit
Conference Location: Providence, RI
Publisher: American Institute of Aeronautics and Astronautics (AIAA)
Date: August 16-19
Electronic Resource Number: AIAA 2004-5038
Author's Title and Affiliation: Jackson: Senior Aerospace Technologist, Dynamics & Control Branch, NASA Langley Research Center
Hildreth: Vice President/Division Manager, SAIC
York: Aerospace Engineer, Naval Air Systems Command
Cleveland: System Engineer, Northrop Grumman Information Technology
Abstract: This paper reports on a study that tested the AIAA Modeling and Simulation Technical Committee's proposed simulation model exchange standard. The motivation for and results of an evaluation of using the standard in an XML-based exchange format for static aerodynamic models between simulation facilities is given. The format is described briefly, along with a description of the two fixed-wing aerodynamic models used in testing. The experiences by two facilities that volunteered to import these test models are given, along with a description of the development of preliminary export tools. Utility programs developed to assist in implementing the standard format are described.
Author Address: Jackson: NASA Langley Research Center, Dynamics & Control Branch, MS 132, Hampton, VA 23681
Hildreth: SAIC, Suite 200, 22299 Exploration Drive, Lexington Park, MD 20653
York: Naval Air Systems Command, Patuxent River, MD 20670
Cleveland: Northrop Grumman Information Technology, Moffett Field, CA 94035

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Reference Type: Report
Author: Jacobs, John W.; Prince, Carolyn; Hays, Robert T.; Salas, Eduardo
Year: 1990
Title: A meta-analysis of the flight simulator training research
City: Orlando, FL
Institution: Naval Training Systems Center
Pages: 1-122
Date: August
Type: Final Report
Report Number: NAVTRASYSCEN TR 89-006
Author's Title and Affiliation: Naval Training Systems Center Human Factors Division, 12350 Research Parkway, Orlando, FL 32826-3224
Recipient's Title and Affiliation: Office of Naval Technology
Number of Pages: 122
Keywords: meta-analysis, flight simulation, training effectiveness, training system design
Abstract: A meta-analysis of flight simulation research was conducted to identify important characteristics associated with the effectiveness of simulator training. A total of 247 articles, research reports, and technical reports were located, of which 26 had sufficient information for statistical meta-analysis; 19 involved jet pilot training and 7 involved helicopter pilot training. The major finding was that the use of simulators consistently produced improvements in training for jets (relative to aircraft training only). No conclusion about simulator effectiveness for helicopter training could be made due to the small number of experiments available for this analysis. Use of motion cueing added little to the training environment for jets, and may have even detracted from the training for some tasks. For helicopters, the effects of motion cueing were not able to be analyzed because of an insufficient number of experiments. Conclusions concerning the benefits of motion cueing for both types of aircraft were considered highly tentative due to methods used when conducting motion-related experiments. In general, training

outcomes appear to be influenced by the type of task and the amount and type of training. An agenda for future research is provided.

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Reference Type: Report
Author: Jacobs, R. S.
Year: 1976
Title: Simulator cockpit motion and the transfer of initial flight training
City: Urbana-Champaign, IL
Institution: Air Force Office of Scientific Research, Air Force Systems Command, United States Air Force
Date: June
Type: Technical Report
Report Number: ARL-76-8/AFOSR-76-4
Author's Title and Affiliation: University of Illinois at Urbana-Champaign, Aviation Research Laboratory, Institute of Aviation
Number of Pages: 79
Keywords: transfer of training, flight training, simulator motion, transfer effectiveness, cost effectiveness, flight simulators, human factors
Abstract: Transfer of flight training from a Singer-Link GAT-2 training simulator, modified to approximate a counterpart Piper Cherokee Arrow airplane, was measured for independent groups of nine flight-naive subjects, each trained in one of three simulator cockpit motion conditions: normal washout motion in bank with sustained pitch angles, washout banking motion in which the direction of motion relative to that of the simulated airplane was randomly reversed 50% of the time as the cab passed through a wings-level attitude, and a fixed-base condition. Subjects received predetermined fixed amounts of practice in the simulator on each of 11 flight maneuvers drawn from the Private Pilot flight curriculum. Transfer of performance measures, including flight time and trials to FAA performance criteria and total errors made in the process, showed reliable transfer for all groups with differential transfer effects and cost effectiveness implications depending upon the type of simulator motion. An aptitude estimator measure and the analysis of covariance technique provided increased discrimination among groups in the presence of considerable individual variation in performance within treatment conditions.

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Reference Type: Journal Article
Author: Jagacinski, Richard J.
Year: 1977
Title: A qualitative look at feedback control theory as a style of describing behavior
Journal: Human Factors
Volume: 19
Issue: 4
Pages: 331-347
Date: August
Author's Title and Affiliation: Ohio State University, Department of Psychology, Columbus, OH
Number of Pages: 17
Abstract: The present paper reviews several ways feedback control theory has been used to describe tracking behavior and several qualitative experimental techniques. These techniques require only ordinal-level measurement and may aid any researcher investigating behavior whose temporal patterning is critical and which involves fairly continuous changes over time. One possible application in the area of stuttering behavior is presented in detail to show how these techniques can provide useful insights and hypotheses. Other suggested areas of application include the behavior of human social groups, motivational behavior, and emotional behavior.

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Reference Type: Conference Paper
Author: Jaspers, Henrik
Year: 2004
Title: Restoring and operating historical aviation trainers
Conference Name: Flight Simulation 1929-2029: A Centennial Perspective
Conference Location: London, UK
Publisher: Royal Aeronautical Society (RAeS)
Date: May 26-27
Abstract: The paper describes a collection of aviation trainers covering a period of twenty years. In brief the development of the techniques applied in aviation trainers from 1937 to 1950 is discussed. A summary is given of the problems of restoring. The altitude systems of the C-3, the C-8 and the C-11 are dealt with in brief, giving an insight in the rapidly increasing complexity over a period of ten years. The importance of giving demonstrations with aviation trainers in public museums is emphasized as a way of educating and amusing the visitors. This could best be done by (retired) pilots. “Flying” a trainer with the hood closed following the instructions of the instructor gives a very special emotion, almost like traveling in time. The paper ends with the hope that somewhere in the world a well known aviation museum will establish a section dedicated to the history of flight simulation.
URL: http://home.wanadoo.nl/hjaspers000/
Author Address: henrikjaspers@hotmail.com; P.O. BOX 57, 4854 ZH Bavel, The Netherlands

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Reference Type: Presentation
Author: Jenkin, Heather L.; Zacher, James E.; Oman, Charles M.; Harris, Laurence R.
Year: 2007
Title: Effect of field of view on a visual reorientation illusion: Does the levitation illusion depend on the view scene or the scene viewed?
Presentation Event: 2007 Symposium on the Role of the Vestibular Organs in Space Exploration
Event Location: The Netherlands
Date: June 7-9
Author's Title and Affiliation: Heather Jenkin, James Zacher, Laurence Harris: Centre for Vision Research, York University
Charles Oman: Massachusetts Institute of Technology (MIT)
Number of Pages: PowerPoint
Keywords: reorientation illusion, disorientation, upset recovery training (URT)
Notes: URL is no longer working (9/30/09).
URL:
http://www.congrex.nl/06a07/presentations/session%2004%20Spatial%20Orientation/04_07_Jenkin.pdf
Author Address: Jenkin: hjenkin@yorku.ca

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Reference Type: Journal Article
Author: Jentsch, Florian; Bowers, Clint A.
Year: 1998
Title: Evidence for the validity of PC-based simulations in studying aircrew coordination
Journal: International Journal of Aviation Psychology (IJAP)
Volume: 8
Issue: 3
Pages: 243-260
Author's Title and Affiliation: Department of Psychology, University of Central Florida, Orlando
Number of Pages: 18
Keywords: PC-based simulations, aircrew coordination, validity, physical validity, convergent validity, discriminate validity, and construct validity
Abstract: Recently, advances in computer technology have allowed the use of PC-based simulations for a variety of aviation training and research purposes. One area in particular where PC-based simulations

have been used extensively is the study of aircrew coordination. Yet, there have always been lingering questions about the validity of these simulations. Critics have argued that most PC-based simulations are derived from video games and that gaming cannot substitute for actual work tasks. Also, the low physical fidelity of these devices has been cited as a potential threat to validity. By reviewing a number of aircrew studies conducted over the past 10 years and by presenting new experimental results, this article provides evidence for the validity of using PC-based simulations. Additionally, this article provides a set of guidelines that can be used by practitioners to increase the validity of their simulations.

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Reference Type: Journal Article
Author: Jentsch, F. G.; Rehfeld, S. A.; Harper, M. E.
Year: 2002
Title: Software: STATISTICA Power Analysis module
Journal: Ergonomics in Design
Volume: 10
Issue: 3
Pages: 28-30
Date: Summer
Type of Article: Review of software
Number of Pages: 3
Abstract: In this review, we focus on a recently improved power analysis module in a popular statistical application, the STATISTICA Power Analysis module. After providing basic information about the program, we focus on the utility and usability of the module. We conclude with a brief example from the literature and the Power Analysis module.

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Reference Type: Book
Author: Jeppesen
Year: 1991
Title: Aviation fundamentals
Publisher: Jeppesen Aviation Training Products

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Reference Type: Report
Author: Jex, Henry R.; Jewell, Wayne F.; Megdaleno, Raymond E.
Year: 1979
Title: Effects of various lateral-beam washouts on pilot tracking and opinion in the "Lamar" simulator
City: Hawthorne, CA
Institution: Systems Technology, Inc
Pages: 244-266
Type: Air Force Flight Dynamics Laboratory Technical Report
Report Number: AFFDL-TR-79-3134
Abstract: A series of moving-base flight simulator experiments was performed using roll and sway motions of the Large Amplitude Multimode Aerospace Research Simulator (LAMARS) of Flight Dynamics Lab WPAFB, OH. The objectives were to:
a) Tie in the roll-only results of the 4 experienced pilots used here with previous results (Ref.1) for 4 well-trained nonpilot subjects.
b) Investigate effects of various lateral-beam-motion "wash-out" filters designed to keep the lateral sway within the +- 10ft or LAMARS travel.
The high-pass washouts on lateral beam travel (y beam) were of the general form: (See report for formula)
The basic task was to follow an evasive (randomly rolling) target while suppressing gust disturbances (Ref.1). A two-independent-input technique produced behavioral data (describing functions) and

performance data (error and control scores), which revealed how pilots used the visual and motion cues. Subjective data was also gathered on the tracking task as well as on limited "sidestep" maneuvers. The main results show: excellent tie-in with prior roll-only experiments with non-pilot subjects; most tracking performance and behavioral parameters were not significantly affected by various degree of sway washout: pilot commentary became more consistent and adverse as the spurious side-force peaks exceeded about 0.1 G y; specific problems were mapped vs. y and Ky.

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Reference Type: Journal Article
Author: Ji, Jennifer T. T.; So, Richard H. Y.; Cheung, Raymond T. F.
Year: 2009
Title: Isolating the effects of vection and optokinetic nystagmus on optokinetic rotation-induced motion sickness
Journal: Human Factors
Volume: 51
Issue: 5
Pages: 739-751
Date: October 2009
Author's Title and Affiliation: Ji and So: Hong Kong University of Science and Technology
Cheung: University of Hong Kong
Number of Pages: 13
Abstract: *Objective:* This study investigates isolated effects of vection and optokinetic nystagmus (OKN) on visually induced motion sickness (VIMS) provoked by rotating optokinetic drum patterns.
Background: VIMS was the subject of recent standardization activities, but the effects of OKN have not been studied in the absence of vection.
Method: Experiment 1 suppressed OKN by eye fixation and examined VIMS severity (both ordinal and ratio scale) and time spent in saturated vection at four pattern rotating velocities of 0, 2, 14, and 34 degrees per second (dps). Experiment 2 suppressed vection by adding a peripheral visual field rotating in the opposite direction to the rotating patterns. VIMS severity and OKN slow-phase velocity were studied at four rotating velocities of 0, 30, 60, and 90 dps.
Results: Results from Experiment 1 indicated that VIMS severity increased as the pattern velocity increased from 0 dps to 34 dps. Results from Experiment 2 indicated that as the velocity of the rotating pattern increased, the slow-phase velocity of OKN and the severity of VIMS increased and peaked in the 60-dps condition. In both experiments, ratio-scaled nausea data significantly correlated with ordinal-scaled nausea ratings.
Conclusion: VIMS can still occur in the absence of either vection or OKN. Interestingly, the profile of the summed results of the two experiments matches nicely with the profile reported by Hu et al. in which neither OKN nor vection were controlled.
Application: Potential applications include modeling and reduction of VIMS in computer gaming environments.

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Reference Type: Report
Author: JIL Information Systems
Year: 1999
Title: Aviation performance measurement system: Flight crew training and management support function
City: Washington, D.C.
Institution: JIL Information Systems, Inc.
Date: September 30
Number of Pages: 103

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Reference Type: Report
Author: JISC Technologies Applications Programme (JTAP)
Year: 2000
Title: JTAP Project 305 Human factors aspects of virtual design environments in education
Institution: JISC Technologies Applications Programme (JTAP)
Pages: 1-151
Date: February
Type: Final Report
Author's Title and Affiliation: Advanced VR Research Center, Loughborough University
Abstract: (taken from 1. Executive Summary)
1.1 Introductory Remarks
This project has concentrated on the human factors issues of interactive virtual design environments. As more and more use is made of 3D design systems (covering CAD and Virtual Design Environments) in higher education establishments there has been an urgent need to understand the complex human-computer aspects of these systems. Apart from the human factors in the use of these tools there is a requirement to understand the implications that may arise when these systems are used in teaching or educational contexts. The results from the study will be extremely important to anyone intending to use these systems for supporting education. Virtual design environments have evolved considerably during the life-span of the project and will revolutionize engineering design by enabling virtual prototyping to be undertaken earlier in the design process. Depending upon the application, immersive or non-immersive VR technologies may be employed. In educational terms, the advantage with virtual prototyping lies with the ability to interact with complex high fidelity 3D engineering data. In this context, the major feature is the ability of the student or designer to interact with the data in an intuitive manner. However, this presents a number of human factors issues that need to be resolved such as required fidelity of representation. Current interaction devices have been devised for 2D interaction and do not lend themselves to 3D applications. This can create additional difficulties when teaching students the use of 3D tools. The student should be able to interact with the virtual environment in a natural manner. Beyond this the student should be able to enter, view and manipulate their virtual designs as though they were in a real design environment, which would otherwise prove difficult or costly and yet is a requisite part of their learning. The ability to do this will profoundly enhance the educational methods and learning experience of such experimentation. The primary objective of the project has been to determine the key human factors aspects of these virtual design environments. Guidance on optimal human factors design principles has been reported in the context of virtual design environments for educational purposes.
URL: http://www.jisc.ac.uk/uploaded_documents/jtap-048.pdf

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Reference Type: Conference Paper
Author: Johnson, C. W.; Dell, W.
Year: 2003
Title: Limitations of 3D audio to improve auditory cues in aircraft cockpits
Conference Name: International Systems Safety Conference
Author's Title and Affiliation: Department of Computing Science, University of Glasgow, Scotland, G12 9QQ
Keywords: accident reporting, media, causal analysis, accident investigation
Abstract: Several organizations, including the FAA and NASA, have sponsored research projects into the use of spatialized audio as a means of improving warnings in commercial aircraft. Other research groups, including the Australian Defence Science and Technology Organization, have explored the use of these techniques within military aviation. A common factor across all of this work is an apparent enthusiasm for the potential benefits of this technology. In contrast, this paper describes the problems that were encountered when attempting to derive empirical evidence for the benefits of 3D auditory cues in aircraft cockpits. Benefits were identified for the stereo presentation of auditory information but it was far harder to demonstrate any additional support for the use of more sophisticated techniques. The second half of this paper extends our investigation beyond the laboratory to examine pragmatic barriers that frustrate the introduction of this technology. These range from the problems of integrating cockpit

warning systems through to an apparent confusion in the recommended practices for headphone use in Europe and North America.
URL: http://www.dcs.gla.ac.uk/~johnson/papers/ISSC2003/3daudio.pdf

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Reference Type: Conference Paper
Author: Johnson, D.
Year: 1978
Title: Visibility modeling for a landing simulator with special reference to low visibility
Conference Name: Flight Mechanics Panel Specialists' Meeting on Piloted Aircraft Environment Simulation Techniques
Conference Location: Brussels, Belgium
Publisher: Advisory Group for Aerospace Research and Development (AGARD)
Date: April 24-27
Author's Title and Affiliation: Royal Aircraft Establishment, Farnborough, Hampshire, England
Number of Pages: 10
Keywords: landing simulator, visual simulation
Abstract: When a simulator is used to demonstrate or investigate the effects of restricted visibility on a pilot's ability to land an aircraft it is important that the visual sequence displayed is as realistic as possible. In this paper the characteristics of the visual world by day and by night are described. In particular the topics of contrast, the apparent horizon and the perception of the lights are considered.
A brief account is also given of the characteristics of some of the more commonly encountered fogs whose effects could usefully be represented in simulating low visibility conditions. These include shallow fogs and those with marked vertical density gradients.
Various ways of simulating the outside world in general are briefly described and discussed in relation to fog and vision.

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Reference Type: Report
Author: Johnson, David M.
Year: 2005
Title: Introduction to and review of simulator sickness research
Institution: U.S. Army Research Institute
Date: April
Report Number: Research Report 1832
Author's Title and Affiliation: U.S. Army Research Institute, Rotary Wing Aviation Research Unit
Keywords: simulator sickness, motion sickness, flight simulation, flight simulators, flight training, helicopter training, motion sickness theory, simulator sickness theory, sensory conflict theory, postural instability theory
Abstract: This report reviews, and explains the research literature pertaining to simulator sickness. Simulator sickness is a form of motion sickness. Consequently, motion sickness is reviewed also. Special emphasis is given to simulator-based flight training--especially helicopter flight training. This review includes the sensory basis of the perception of motion, the terminology of motion sickness and simulator sickness, a selected history of these research fields, sickness signs and symptoms, measurement issues, incidence of sickness, residual aftereffects, adaptation to a novel motion environment, susceptibility factors, performance issues, training issues, safety issues, treatment, theory, guidelines for simulator-based flight training, and suggestions for further research. The sensory conflict theory and the postural instability theory are described insofar as they relate to motion sickness and to simulator sickness. The effect of simulator sickness on training effectiveness, if any, remains a subject of future applied research.
URL: http://www.hqda.army.mil/ari/pdf/RR%201832.pdf

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Reference Type: Report
Author: Johnson, David M.; Stewart, John E. II
Year: 2002
Title: Utility of a Personal Computer Aviation Training Device for helicopter flight training
Institution: U.S. Army Research Institute for the Behavioral and Social Sciences
Date: February
Type: Research Report
Report Number: 1787
Number of Pages: 47
Keywords: flight training, simulation, aircrew training programs, helicopter training
Abstract: Personal Computer Aviation Training Devices (PCATDs) have recently been shown to support beginning flight training both in the private sector and the military. These positive results are for fixed-wing aircraft only. The purpose of this research was to investigate which tasks from Initial Entry Rotary Wing (IERW) training could be supported by PCATD. A utility evaluation was performed. Sixteen aviators, representing both highly experienced and student helicopter pilots, evaluated the ability of a commercial PCATD to support IERW. Seventy-one tasks were selected from Primary and Instrument Flight Training. Aviators performed each task one or more times in the PCATD before rating it on a four-point scale. Additional data were also collected. Results showed remarkable agreement between the experienced aviators and the students. The device was judged as best able to support Instrument Flight Training, especially tasks involving radio navigation. Tasks from Primary Flight Training, especially tasks requiring hovering, were judged as less well supported. The most frequently stated positive comment was that the device would be of value in supporting the training of instrument procedures. The three most frequently cited criticisms of the device concerned narrow field of view, poor visual cues to depth, and inability to hover.

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Reference Type: Web Page
Author: Johnson, Glen
Year: 1999
Title: Near miss spurs new pilot training
Publisher: Mercury News
Access Year: 2006
Access Date: Sept. 6
Number of Pages: 3
Abstract: As Flight 863 lifted off the runway for its 14-hour, 25-minute journey, it was hit with one of the most practiced airplane emergencies, a failed engine. The plane's right inboard engine, one of four mounted on the wings, stalled. The co-pilot, who was flying the plane, correctly responded by shutting it down. Because it was overpowered on the left, the plane started to turn to the right. The correct response would have been stepping on the left rudder pedal, which would straighten the nose. Instead the pilot turned the control wheel to the left. That deployed panels on the plane's wing, reducing its lift, which led the plane towards San Bruno Mountain. Fortunately, the plane did clear the mountain.
Notes: On September 6, 2006 the original web page was no longer accessible.
URL: http://forums.sjmercury.com/nation/nationwire/docs/2569731.htm

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Reference Type: Report
Author: Johnson, Peder J.; Goldsmith, Timothy E.
Year: 1998
Title: The importance of quality data in evaluating aircrew performance
Institution: Federal Aviation Administration (FAA)
Pages: 1-37
Date: May
Type: Technical Report
Number of Pages: 37

Abstract: The primary goal of this chapter is to describe a set of methods and procedures that will enhance the quality of the data to assess aircrew performance. The two fundamental properties of quality data are reliability and validity. This section begins with a formal discussion of these two ideas, including a description of the statistics used to estimate reliability. After giving a formal treatment of reliability and validity we next discuss these concepts in the context of aircrew performance assessment. Here our discussion will be concerned with the three primary factors that influence the overall quality of data. The first is the observer or evaluator who must make the judgments or ratings of the observed performance. The second is the measuring instrument (e.g., a Line-Oriented Evaluation [LOE] grade sheet) that is used to collect data. The third factor is the host of parameters that comprise the assessment situation (e.g., a calibration session). As a brief aside it is important to understand that the assessment situation is often not the same situation under which assessments are normally conducted. For example, in a calibration session the evaluators will observe and judge a video of a crew flying an LOE as opposed to judging an LOE simulated flight. This is necessary because in order to estimate reliability every evaluator must observe the identical crew performance. The video is necessary because it would pose some obvious logistical problems to arrange for 20 or more evaluators to observe an actual LOE in the simulator. Returning to the central point of discussion, when we refer to the parameters of the assessment situation, it must be understood that they are not always the same as the conditions under which these types of observations are normally made.

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Reference Type: Conference Paper
Author: Johnson, W. W.; Kaiser, M. K.
Year: 1995
Title: Perspective imagery in synthetic scenes used to control and guide aircraft during landing and taxi: Some issues and concerns
Conference Name: SPIE Conference on Synthetic Vision for Vehicle Guidance and Control
Conference Location: Orlando, FL
Publisher: International Society for Optical Engineering (SPIE)
Author's Title and Affiliation: NASA Ames research center, Flight Management and Human Factors Division, Moffett Field, CA 94035
Number of Pages: 11
Keywords: synthetic vision, cockpit displays, perspective displays, display conformality, human factors
Abstract: Perspective synthetic displays that supplement, or supplant, the optical windows traditionally used for guidance and control of aircraft are accompanied by potentially significant human factors problems related to the optical geometric conformality of the display. Such geometric conformality is broken when optical features are not in the location they would be if directly viewed through a window. This often occurs when the scene is relayed or generated from a location different from the pilot's eyepoint. However, assuming no large visual/vestibular effects, a pilot can often learn to use such a display very effectively. Important problems may arise, however, when display accuracy or consistency is compromised, and this can usually be related to geometrical discrepancies between how the synthetic visual scene behaves and how the visual scene through a window behaves. In addition to these issues, this paper examines the potentially critical problem of the disorientation that can arise when both a synthetic display and a real window are present in a flight deck, and no consistent visual interpretation is available.

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Reference Type: Conference Paper
Author: Johnson, Walter W.; Schroeder, Jeffery A.
Year: 1995
Title: Visual-motion cueing in the control of altitude
Conference Name: 1995 IEEE International Conference on Systems, Man, and Cybernetics
Conference Location: Vancouver, British Columbia, Canada
Date: October

Author's Title and Affiliation: NASA Ames Research Center, Mail Stop 262-3, Moffett Field, CA 94035-1000
Number of Pages: 6
Abstract: The Vertical Motion Simulator at the NASA Ames Research Center was used to examine how platform motion and visual level of detail (LOD) cueing affected altitude repositioning and vertical rate control in two tasks utilizing a simulated AH-64 Apache helicopter. The LOD manipulation caused optical density to change across altitudes by a small, moderate, or large amount. The platform motion manipulation resulted in platform motion being either present, and 1:1 (full), or totally absent. Both small optical density changes and platform motion improved altitude judgments in the altitude repositioning task, while platform motion improved performance in a vertical rate control task. These findings show that 1) vertical platform motion mitigates the tendency of pilots to mistake optical flow rate (angular visual speed) as proportional to vehicle speed during altitude change, and contributes to the perception of movement amplitude; and 2) maintaining nearly constant optical density across altitudes improves altitude judgments.

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Reference Type: Report
Author: Johnston, D. E.; Aponso, B. L.
Year: 1988
Title: Design considerations of manipulator and feel system characteristics in roll tracking
Series Editor: NASA Scientific and Technical Information Division
Institution: Systems Technology, Inc.
Pages: 1-227
Type: NASA Contractor Report
Report Number: NASA Contractor Report 4111
Author's Title and Affiliation: Systems Technology, Inc., Hawthorne, CA
Recipient's Title and Affiliation: National Aeronautics and Space Administration (NASA), Washington, DC 20546
Number of Pages: 228
Keywords: arm (anatomy,) control sticks, control systems design, controllers, design analysis, flight characteristics, flight control, man machine systems manipulators, neurophysiology, pilot performance, roll, sensorimotor performance, touch, tracking (position), human reactions, rates (per time), simulation, time lag
Abstract: A fixed-base simulation was performed to identify and quantify interactions between the pilot's hand arm neuromuscular subsystem and such control system features of typical modern fighter aircraft roll rate command mechanizations as (1) force versus displacement sensing side-stick type manipulator, (2) feel force displacement gradient, (3) feel system versus command prefilter dynamic lag, and (4) flight control system effective time delay. The experiment encompassed some 48 manipulator filter aircraft configurations. Displacement side-stick experiment results are given and compared with the previous force sidestick experiment results. Attention is focused on control bandwidth, excitement (peaking) of the neuromuscular mode, feel force displacement gradient effects, time delay effects, etc. Section 5 is devoted to experiments with a center-stick in which force versus displacement sensing, feel system lag, and command prefilter lag influences on tracking performance and pilot preference are investigated.
URL: http://ntrs.nasa.gov/search.jsp?R=170264&id=1&qs=N%3D4294819006

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Reference Type: Unpublished Work
Author: Johnston, Neil
Year: 1995
Title of Work: Simulation and training: Perspectives on theory and practice
City: Dublin, Ireland
Institution: Aerospace Psychology Research Group, Trinity College
Date: August
Number of Pages: 27

Abstract: Fundamental to the design of effective simulation and training is some understanding as to the nature of human learning. This paper suggests that the conventional simulation and pilot training wisdom is based upon deficient models of learning. The paper is in two parts; Part 1 broadly considers theory, while Part 2 looks to the implications for simulation and training. Given that the favored approach to training is derived from a combination of newly developing training principles, philosophical and theoretical aspects are considered in Part 1. Ideas and perspectives from research into Naturalistic Decision Making, Human Expertise, Cognitive Task Analysis, Situated Learning and Phenomenology are also reviewed. In Part 2 preliminary conclusions are drawn and implications for simulation and training practice are discussed, including criteria for "low fidelity" simulation techniques. The overall objective of the paper is to contribute to the task of building a new foundation for the design and implementation of training.

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Reference Type: Report
Author: Joint Aviation Authorities
Year: 2006
Title: JAR-FCL 1 - Flight Crew Licensing (Aeroplane)
Series Title: Joint Aviation Requirement
City: Hoofddorp, Netherlands
Institution: JAA
Document Number: 09/44-1/06-L598
Date: December 1

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Reference Type: Report
Author: Joint Safety Analysis Team (JSAT)
Year: 1999
Title: Approach and landing
Institution: JSAT
Date: September 10
Number of Pages: 188
Abstract: [first paragraph of Executive Summary] In the summer of 1998, the Commercial Aviation Safety Team (CAST) chartered the Approach and Landing Joint Safety Analysis Team (JSAT) to review and analyze data for the purpose of developing and recommending interventions that will enhance commercial aviation safety during the approach and landing phase of flight by 2007. The JSAT's data included publicly available source information, accident reports, and other approach and landing studies.

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Reference Type: Report
Author: Jones, Edward R.; Hennessy, Robert T.
Year: 1985
Title: Human factors aspects of simulation
City: Washington, DC
Institution: National Academy Press
Pages: 147
Keywords: simulation, man machine systems, environments, performance (human), human factors engineering, time, savings
Abstract: The increasing importance and pervasiveness of simulation are due to several factors including cost and time savings that can be realized in system design and training, the ability to reproduce and examine situations that would be unsafe using actual equipment, the control and measurement of human-machine performance in a benign environment, and the capability to investigate conditions that would be impractical to arrange otherwise. Shortcomings in the use of current simulators are described and recommendations are made for research needed to enhance the value and use of simulators.

Reference Type: Conference Paper
Author: Junker, A. M.; Price, D.
Year: 1976
Title: Comparison between a peripheral display and motion information on human tracking about the roll axis
Conference Name: AIAA Visual and Motion Simulation Conference
Conference Location: Dayton, OH
Publisher: American Institute of Aeronautics and Astronautics (AIAA)
Date: April 26-28
Electronic Resource Number: AIAA-1976-1708
Author's Title and Affiliation: Junker: Aerospace Medical Research Laboratory, Wright-Patterson Air Force Base, OH
Price: Air Force Institute of Technology, Wright-Patterson Air Force Base, OH
Number of Pages: 8
Abstract: A comparative study of the effects of peripheral display information and motion cue information on roll axis tracking was performed. It has been shown that similar motion information improves tracking performance for some roll axis tracking tasks. For the motion case the cues available consisted of angular acceleration or velocity and linear acceleration. The peripheral display was driven by plant roll rate giving the human operator angular velocity information only. The same input forcing function and plant dynamics were used for the motion case and the peripheral display case so that the comparison could be made. The tracking results indicate an equivalent improvement in performance for both cases suggesting that angular velocity information was the principal motion component used by the human controller. The results also suggest that peripheral displays can be used to enhance tracking in much the same way as motion cues for tracking performance.

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Reference Type: Presentation
Author: Kaemph, George L.
Year: 1992
Title: Development of integrated measures of cockpit resource management and technical performance for the advanced qualification program
Date: June 1
Author's Title and Affiliation: Ph.D., Klein Associates Inc., Fairborn, OH
Keywords: Crew resource management, CRM, Advanced Qualification Program, AQP, performance measures, knowledge elicitation techniques

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Reference Type: Report (Interim)
Author: Kaemph, George L.; Cross, Kenneth D.; Blackwell, Joan N.
Year: 1989
Title: Backward transfer and skill acquisition in the AH-1 flight and weapons simulator
City: Fort Rucker, AL
Institution: Anacapa Sciences, Inc.
Date: August
Report Number: ARI (monitoring organization) Research Report 1537
Anacapa Sciences (performing organization) 690-312-88
Author's Title and Affiliation: Kaempf, Cross: Anacapa Sciences, Inc., P.O. Box 489, Fort Rucker, AL 36362; Blackwell: U.S. Army Research Institute Aviation, Research and Development Activity
Recipient's Title and Affiliation: Army Research Institute Aviation Research and Development Activity, Fort Rucker, AL 36362
Number of Pages: 48+
Keywords: flight simulation, skill acquisition, aircrew training, helicopter, training effectiveness, pilot performance, backward transfer, transfer of training
Abstract: Two experiments were conducted, one to investigate the backward transfer of flight skills to the AH-1 Flight and Weapons Simulator (AH1FWS) and another to investigate the acquisition of flight skills in the AH1FWS on selected maneuvers. In the backward transfer research, 16 AH-1 instructor pilots (IPs) from the AH-1 Aircrew Qualification Course were administered checkrides in the AH1FWS and the AH-1F aircraft. Comparison of the performance data from the two checkrides indicates that, while proficient on the maneuvers in the AH-1F, all IPs performed poorly in the AH1FWS. The IPs attributed their difficulties in the AH1FWS to deficiencies in the visual system and the handling and response characteristics of the flight controls. In the skill acquisition research, four groups of 10 operational aviators received training in the AH1FWS. Each group received training on a different set of five maneuvers. The training comprised 10 practice trials for each maneuver. Subjects received no feedback on trials 1-3; IPs provided instruction on trials 4-10. Mean performance ratings did not reach a satisfactory level of proficiency within the 10 practice trials for 17 of the 20 maneuvers investigated. Furthermore, the backward transfer data obtained during the skill acquisition research were consistent with similar data collected in a previous study.

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Reference Type: Report
Author: Kaemph, George L.; Klinger, David W.
Year: 1993
Title: Integrated measurement of crew resource management and technical flying skills
City: Fairborn, OH
Institution: Klein Associates
Date: August
Type: Final Report
Report Number: DOT/FAA/RD-93/26
DOT-VNTSC-FAA-93-6
Number of Pages: 113
Keywords: human factors, evaluation, cockpit resource management, CRM, line oriented flight training

Abstract: This report presents the findings of a study designed with two objectives: to produce a prototype performance measurement instrument (PMI) that integrates the assessment of Crew Resource Management (CRM) and technical flying skills and to investigate the suitability of the Critical Decision method (CDM) for eliciting expert information concerning performance measurement. The work was funded by the FAA in support of the Advanced Qualification Program (AQP) and conducted in cooperation with a major U.S. carrier. The researchers used CDM to identify critical components of performance assessment for specific flight tasks and developed a prototype PMI. The instrument contains two sections for each task. One section allows an evaluator to record significant pilot and crew behaviors observed; the second section allows the evaluator to provide a subjective assessment of pilot and crew proficiency. The researchers pretested the instrument and made revisions based on recommendations from experienced instructors. The researchers then evaluated the PMI with eight instructors observing a total of 16 different flight crews in recurrent training, performing a standard Line Oriented Flight Training (LOFT) scenario in a flight simulator. The instructors reliably and accurately employed the PMI to assess performance of the crew and the individual pilot. The authors recommended that AQP developers use Cognitive Task Analysis (CTA) techniques to develop training programs for cognitive and team tasks.

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Reference Type: Book Section
Author: Kaiser, M. K.; Schroeder, J. A.
Year: 2003
Title: Flights of fancy: The art and science of flight simulation
Editor: Tsang, P.; Vidulich, M.
Book Title: Principles and Practice of Aviation Psychology
City: Mahwah, NJ
Publisher: LEA
Author's Title and Affiliation: NASA Ames Research Center

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Reference Type: Journal Article
Author: Kallus, K. Wolfgang; Tropper, Karin
Year: 2004
Title: Evaluation of a spatial disorientation training for jet pilots
Journal: International Journal of Applied Aviation Studies
Volume: 4
Issue: 1
Pages: 45-55
Author's Title and Affiliation: Karl-Franzens-University Dep. of Psychology
Keywords: spatial disorientation, upset recovery training (URT)
Abstract: To evaluate the efficiency of a disorientation-recovery program using the Airfox DISO flight simulator (Disorientation Trainer, AMST Systemtechnik GmbH, Austria), 26 jet pilots were tested. The pilots were randomly allocated to one of three groups: Training, Awareness, or Control Group. The training for the Training group included demonstration trials of the disorientation phenomena Gyro Spin, Leans, Dark Take-off, Expectation Error, Black Hole Approach, and False Horizon (awareness phase) and additional reorientation exercises (training phase). Pilots in the Awareness group also received the awareness phase, but instead of the training phase, they had the control condition free flight. All 26 pilots attended a test, which included profiles of disorientation elements. The whole procedure took about seven hours per pilot. Aviation performance, psychological, and physiological data were measured. Results contribute to answer the more theoretical question how physiologically determined perceptual illusions and contradicting perceptual inputs to the mental picture of the situation interact to change or destroy situation awareness. Physiological stress occurred during the simulator exercises (e.g. Black Hole Approach) as indicated by significant changes in heart rate. Performance ratings show positive effects for the Training group. The Training group recovered more quickly, confirming these ratings.
Author Address: Universitätsplatz 2/III, A-8010 Graz, Austria; wolfgand-kallus@uni-graz.at

Reference Type: Presentation
Author: Kapralos, B.; Zikovitz, D.; Jenkin, M.; Harris, L. R.
Year: 2003
Title: Auditory cues in the perception of self motion
Date: October 17
Type: PowerPoint presentation
Author's Title and Affiliation: York University, North York Ontario, Canada
Kapralos: Department of Computer Science, Center for Vision Research
Zikovitz: Department of Biology, Center for Vision Research
Jenkin: Department of Computer Science, Center for Vision Research
Harris: Department of Biology, Department of Psychology, Center for Vision Research

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Reference Type: Report
Author: Karlins, Marvin; Koh, Freddie; McCully, Len; Chan, C.T.
Year: 1997
Title: Cockpit resource management videos
Institution: Federal Aviation Administration (FAA)
Author's Title and Affiliation: Karlins - Professor of Management, University of South Florida
Koh - Assistant Director of Flight Operations, Singapore Airlines
McCully - Assistant Director of Flight Operations, Singapore Airlines
Chan - Deputy of Chief Pilot, Singapore Airlines

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Reference Type: Journal Article
Author: Kasai, Takeshi; Zee, David S.
Year: 1978
Title: Eye-head coordination in labyrinthine-defective human beings
Journal: Brain Research
Volume: 144
Issue: 1
Pages: 123-141
ISSN: 0006-8993 (Print)
Electronic Resource Number: 10.1016/0006-8993(78)90439-0
Number of Pages: 19
Accession Number: 1980-07852-001
Keywords: patterns of adaptive responses to achieve optimal gaze stability in eye-hand coordination, 45-55 yr olds with absent labyrinthine function
Abstract: Eye–head coordination was studied in 3 45–55 yr old college teachers with absent labyrinthine function. Each S adopted a unique pattern of adaptive responses to achieve optimal gaze stability: (a) One S used saccades (even in darkness) to help stabilize gaze. In addition, during rotation of the body with the head stationary in darkness, he made slow and quick phases of nystagmus in the same direction. (b) To help prevent gaze overshoot, the 2nd S showed a decrease in the saccadic amplitude–retinal error relationship selectively during active combined eye–head movements. (c) The 3rd S showed a significant amount of preprogramming of compensatory slow phases independent of actual head motion. In all Ss, the passively induced cervico-ocular reflex was moderately potentiated, accounting for about 25% of compensation for head motion during active target seeking; effort of spatial localization, as shown by imagining targets in total darkness, increased the velocity of compensatory slow phases to near that of head movements during head rotations; and gaze stability was enhanced during tracking of targets jumping in a predictable fashion. The choice of strategies used by each S may depend, in part, upon the latency of the cervico-ocular reflex during active head movements. (15 ref) (PsycINFO Database Record (c) 2009 APA, all rights reserved)

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Reference Type: Electronic Article
Author: Keiver
Year: 2009
Title: Simulation in aviation
Periodical Title: On Target
Issue: Human Factors
Pages: 12-15
Author's Title and Affiliation: Lieutenant-Colonel Keiver, 1 Canadian Air Division, Winnipeg
URL: http://www.airforce.forces.gc.ca/dfs-dsv/pub/nr-sp/index-eng.asp?id=10276

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Reference Type: Conference Proceedings
Author: Keller, Jeffrey D.; McKillip, Robert M. Jr.; Kim, Sungwan
Year of Conference: 2009
Title: Aircraft flight envelope determination using upset detection and physical modeling methods
Conference Name: AIAA Guidance, Navigation, and Control Conference
Conference Location: Chicago, IL
Publisher: American Institute of Aeronautics and Astronautics (AIAA)
Pages: 1-21
Date: Aug. 10-13
Electronic Resource Number: AIAA-2009-6259
Author's Title and Affiliation: Keller: Associate, Continuum Dynamics, Inc., Ewing, NJ
McKillip: Senior Associate, Continuum Dynamics, Inc., Ewing, NJ
Kim: Senior Research Engineer, NASA Langley Research Center, Hampton, VA
Number of Pages: 21
Keywords: flight envelope, fault detection, upset recovery training (URT)
Abstract: The development of flight control systems to enhance aircraft safety during periods of vehicle impairment or degraded operations has been the focus of extensive work in recent years. Conditions adversely affecting aircraft flight operations and safety may result from a number of causes, including environmental disturbances, degraded flight operations, and aerodynamic upsets. To enhance the effectiveness of adaptive and envelope limiting controls systems, it is desirable to examine methods for identifying the occurrence of anomalous conditions and for assessing the impact of these conditions on the aircraft operational limits. This paper describes initial work performed toward this end, examining the use of fault detection methods applied to the aircraft for aerodynamic performance degradation identification and model-based methods for envelope prediction. Results are presented in which a model-based fault detection filter is applied to the identification of aircraft control surface and stall departure failures/upsets. This application is supported by a distributed loading aerodynamics formulation for the flight dynamics system reference model. Extensions for estimating the flight envelope due to generalized aerodynamic performance degradation are also described.

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Reference Type: Thesis
Author: Kellogg, Robert S.
Year: 1971
Title: Static and dynamic ocular counterrolling in normal and bilaterally labyrinthine defective subjects
Academic Department: Dissertation Abstracts International
Degree: 32
Date: 1971
Keywords: static & dynamic ocular counterrolling, rotation rate & direction, normal & bilaterally labyrinthine defective Ss
Notes: Dissertation abstract

Reference Type: Conference Paper
Author: Kemeny, A.
Year: 1999
Title: Simulation and perception
Conference Name: Driving Simulation Conference
Conference Location: Paris, France
Date: July
Abstract: (Taken from 1. Introduction) A driving simulator consists of a vehicle and an engine of sensory stimuli producing the virtual environment. This virtual environment acts onto the driver at both perceptional and cognitive levels. Perceptional cueing is mainly visual, auditory and kinesthetic. Cognitive processes allow the driver to better sense the environment, infrastructure (horizontal and vertical road signs) and traffic, by performing driving tasks using these information, both perceptional and cognitive. Due to the human sensibility to cueing incoherence and sensory conflicts, especially regarding the perception of motion, it is essential to respect the characteristics of human perception systems. In the following, we shall review the influence of visual, vestibular, muscular and musculo-articular receptors on the characteristics of visual and kinesthetic rendering systems to take into account.
URL: http://www.experts.renault.com/DSC99/papers/INTROVA.PDF
Author Address: andras.kemeny@renault.fr

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Reference Type: Conference Paper
Author: Kemmerling, Paul T., Jr.
Year: 1978
Title: Dynamic characteristics of flight simulator motion systems
Conference Name: Flight Mechanics Panel Specialists' Meeting on Piloted Aircraft Environment Simulation Techniques
Conference Location: Brussels, Belgium
Publisher: Advisory Group for Aerospace Research and Development (AGARD)
Date: April 24-27
Author's Title and Affiliation: Kemmerling: Lt. Col., USAF, Director, Equipment Engineering, Deputy for Engineering, Aeronautical Systems Division, Wright-Patterson AFB, OH 45433
Number of Pages: 20
Keywords: motion
Abstract: Recognition is made of the complete lack of substantive data on the quality of motion produced by multiple degree of freedom aircraft simulator motion systems, and efforts made to produce this data are discussed. Working Group #07 of the Flight Mechanics Panel of AGARD has been given the charter to identify and define the pertinent physical characteristics of flight simulator motion systems, establish procedures for their measurement and prepare a report of their findings. The seven main characteristics identified by the Group are outlined, and efforts by several of the members to apply the characteristic techniques in laboratory measurements are discussed. Acknowledgment is made of the difficulties in establishing universally workable definitions and techniques for cataloging motion characteristics, and alternatives are suggested. The conclusion is reached that a taxonomy of motion characteristics is a valuable asset in determining the optional use of currently available motion systems.

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Reference Type: Conference Paper
Author: Kennedy, R. S.; Berbaum, G. O.; Allgood, G. O.; Lane, N. E.; Lilienthal, M. G.; Baltzley, D. R.
Year: 1987
Title: Etiological significance of equipment features and pilot history in simulator sickness
Conference Name: Aerospace Medical Panel Symposium on Motion Cues in Flight Simulation and Simulator Induced Sickness
Conference Location: Brussels, Belgium
Publisher: Advisory Group for Aerospace Research and Development (AGARD)
Date: September 29

Author's Title and Affiliation: Kennedy, Berbaum, Lane & Baltzley: Essex Corporation, 1040 Woodcock Road, Suite 227, Orlando, FL 32803
Allgood: Martin Marietta Energy Systems, Inc., P.O. Box X, Oak Ridge, TN 37831
Lilienthal: Naval Training Systems Center, Human Factors Division (711), Orlando, FL 32813-7100
Number of Pages: 22
Keywords: simulator sickness, etiological factors, visual, motion, vestibular
Abstract: The U.S. Navy has conducted a survey in 10 flight trainers where motion experience questionnaires and performance tests were administered to pilots before and after some 1200 separate exposures. From these measures on pilots, several findings emerge: a) specific histories of motion sickness were predictive of simulator sickness symptomatology; b) postural equilibrium was degraded after hops in some simulators; c) self-reports of motion sickness symptomatology revealed three major symptom clusters: gastrointestinal, visual and vestibular; d) certain pilot experiences in simulators and aircraft were related to severity of symptoms experienced; e) simulator sickness incident varied from 10-60%; f) substantial perceptual adaptation occurs over a series of hops; g) in two moving base flight trainers motion sickness incidence appeared to be related to the amount of acceleration (energy) experienced in frequency ranges around 0.2 Hz.
The findings are discussed in the context of sensory conflict theory and recommendations are made for simulator design criteria. Suggestions are made for how to relate simulator and equipment configuration to the separate symptom clusters as an aid to diagnosis of specific problems within particular simulators. We believe this holds promise in diagnosing simulator equipment problems (e.g. alignment, inertial motion profile, cue asynchrony) since different symptom clusters may be related to different equipment features.
URL: http://stinet.dtic.mil/oai/oai?verb=getRecord&metadataPrefix=html&identifier=ADA202492

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Reference Type: Book Section
Author: Kennedy, Robert S.; Berbaum, Kevin S.; Lilienthal, Michael G.
Year: 1992
Title: Human operator discomfort in virtual reality systems: Simulator sickness--causes and cures
Editor: Kumar, Shrawan
Book Title: Advances in industrial ergonomics and safety
City: Washington, DC
Publisher: Taylor and Francis
Volume: IV
Pages: 1227 -1234
Number of Pages: 8

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Reference Type: Journal Article
Author: Kennedy, Robert S.; Fowlkes, Jennifer E.
Year: 1992
Title: Simulator sickness is polygenic and polysymptomatic: Implications for research
Journal: International Journal of Aviation Psychology (IJAP)
Volume: 2
Issue: 1
Pages: 23-38
Number of Pages: 16
Keywords: simulator sickness, polygenic, polysymptomatic
Abstract: The usefulness of visually based flight simulators for training may be compromised by the phenomenon of simulator sickness. Although a significant problem, design specifications for alleviation of simulator sickness have not yet been produced. The problems researchers face in this area are multiple: (a) Simulator sickness is polygenic, rendering experimental isolation of variables ineffective; (b) simulator sickness is polysymptomatic, which must be reflected in measurements of the human response; and (c) there are statistical limitations including limited sample sizes, adaptation over flights, small effect sizes,

and large individual differences. These problems render certain research and engineering strategies more effective than others. Our conclusions, based on analysis of a large data base and statistical power calculations, suggest that improved simulator-design criteria can best be studied in "field experiments" in which large sample sizes permit the relatively small effects of several different simulator-equipment features to be isolated, contrasted, and revealed.
URL: http://www.leaonline.com/doi/pdf/10.1207/s15327108ijap0201_2

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Reference Type: Conference Paper
Author: Kennedy, Robert S.; Jones, Marshall B.; Lilienthal, Michael G.; Harm, Deborah L.
Year: 1993
Title: Profile analysis of after-effects experiences during exposure to several virtual reality environments
Conference Name: 76th Aerospace Medical Panel Meeting on Virtual Interfaces Research and Applications
Conference Location: Lisbon, Portugal

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Reference Type: Journal Article
Author: Kennedy, Robert S.; Lane, Norman E.; Berbaum, Kevin S.; Lilienthal, Michael G.
Year: 1993
Title: Simulator Sickness Questionnaire: An enhanced method for quantifying simulator sickness
Journal: International Journal of Aviation Psychology
Volume: 3
Issue: 3
Pages: 203-220
Author's Title and Affiliation: Kennedy and Lane: Essex Corporation, Orlando, FL
Berbaum: University of Iowa
Lilienthal: U.S. Navy, Washington, DC
Keywords: simulator sickness
Abstract: Simulator sickness (SS) in high-fidelity visual simulators is a byproduct of modern simulation technology. Although it involves symptoms similar to those of motion-induced sickness (MS), SS tends to be less severe, to be of lower incidence, and to originate from elements of visual display and visuo-vestibular interaction atypical of conditions that induce MS. Most studies of SS to date index severity with some variant of the Pensacola Motion Sickness Questionnaire (MSQ). The MSQ has several deficiencies as an instrument for measuring SS. Some symptoms included in the scoring of MS are irrelevant for SS, and several are misleading. Also, the configural approach of MSQ is not readily adaptable to computer administration and scoring. This article describes the development of a Simulator Sickness Questionnaire (SSQ), derived from the MSQ using a series of factor analyses, and illustrates its use in monitoring simulator performance with data from a computerized SSQ survey of 3,691 simulator hops. The database used for development included more than 1,100 MSQs, representing data from 10 Navy simulators. The SSQ provides straightforward computer or manual scoring, increased power to identify "problem" simulators, and improved diagnostic capability.
URL: http://www.leaonline.com/doi/pdf/10.1207/s15327108ijap0303_3

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Reference Type: Conference Proceedings
Author: Kennedy, Robert S.; Lilienthal, Michael G.; Fowlkes, Jennifer E.
Year of Conference: 1991
Title: What needs doing about simulator sickness?
Conference Name: AIAA Flight Simulation Technologies Conference
Conference Location: New Orleans, LA
Publisher: American Institute of Aeronautics and Astronautics (AIAA)
Pages: 489-495

Date: August
Electronic Resource Number: AIAA-91-2974-CP
Author's Title and Affiliation: Kennedy: Essex Corporation, Orlando, FL
Lilienthal: Naval Air Systems Command, Washington, DC
Fowlkes: Essex Corporation, Orlando, FL (Dr. Fowlkes is now located at Engineering and Economics Research, Inc., Orlando, FL)
Number of Pages: 7
Keywords: simulator sickness, virtual environment technology
Abstract: The usefulness of simulators may be compromised by a phenomenon know as simulator sickness. Until research determines how to design simulators that produce no or acceptably low incidence of sickness, there are at least two issues which require attention: (1) simulator monitoring techniques to identify when simulation systems begin to produce unacceptably high levels of sickness, and (2) identification of crewmembers who are at risk for simulator-induced posteffects. This paper describes the development and implementation of a free-standing device that utilizes human output (i.e., symptomatology) to address two questions: (1) is the simulator sick? and (2) is the crewmember sick? The first question is a systems engineering question and pertains to quality assurance testing of simulators. The incidence of simulator sickness symptomatology can be tracked over time for a given simulator using a "quality control" model to detect shifts in calibration or other gradually emerging problems. The second question pertains to biomedical evaluation; crewmembers who exhibit extreme reactions during simulator training are at risk for posteffects and need to be identified so they can be warned with regard to post-training activities. A fielded prototype system has demonstrated that such a system can have: (1) sensitivity to factors which may be expected to affect systems performance, (2) economy in terms of cost and crewmember time, (3) high reliability, and (4) good user acceptance. The profile of the symptomatology holds promise for identifying and targeting the equipment features which, when fixed, will alleviate the problem. A recommendation is made that a technical data base be assembled from a series of field experiments where "naturally occurring" changes to the equipment be monitored "pre," "per," and "post" modification in very large samples (>100) of pilot exposures.

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Reference Type: Journal Article
Author: Keselman, H. J.; Algina, J.; Kowalchuck, R. K.
Year: 2001
Title: The analysis of repeated measures designs: A review
Journal: British Journal of Mathematical and Statistical Psychology
Volume: 54
Pages: 1-20
Author's Title and Affiliation: H. J. Keselman: University of Manitoba, Canada
James Algina: University of Florida
Rhonda K. Kowalchuck: University of Manitoba, Canada
Number of Pages: 21
Abstract: Repeated measures ANOVA can refer to many different types of analysis. Specifically, this vague term can refer to conventional tests of significance, one of three univariate solutions with adjusted degrees of freedom, two different types of multivariate statistic, or approaches that combine univariate and multivariate tests. Accordingly, it is argued that, by only reporting probability values and referring to statistical analyses as repeated measures ANOVA, authors convey neither the type of analysis that was used nor the validity of the reported probability value, since each of these approaches has its own strengths and weaknesses. The various approaches are presented with a discussion of their strengths and weaknesses, and recommendations are made regarding the 'best' choice of analysis. Additional topics discussed include analyses for missing data and tests of linear contrasts.

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Reference Type: Thesis
Author: Kesserwan, Nader
Year: 1999
Title: Flight Simulation
Academic Department: School of Computer Science
City: Montreal, Canada
University: McGill University
Degree: M.Sc.
Date: March
Abstract: Simulation is the technique by which a physical system can be represented mathematically by a computer program for the solution of a problem. This technique of problem solving is used when it is not feasible due to time, cost, or safety to conduct specific tests using the actual physical system, such as an aircraft. A mathematical model is developed for the physical system using knowledge of the physical laws describing the problem. This model is then programmed on the computer to generate the problem solution. The digital computer program represents a discrete approximation of the real world system which is usually continuous. My contribution to this work involves searching and collecting information, studying a case about environmental simulation, implementing a miscellaneous function that is used by pilots during their training on a flight simulator, presenting the history of flight simulation, writing the conclusion and raising questions at the end. In my opinion, raising questions and pointing out problems is as important as finding answers and solutions.
URL: http://www.collectionscanada.ca/obj/s4/f2/dsk1/tape7/PQDD_0018/MQ55071.pdf

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Reference Type: Conference Paper
Author: Key, David L.; Odneal, Billy L.; Sinacori, John B.
Year: 1978
Title: Mission environment simulation for Army rotorcraft development-requirements and capabilities
Conference Name: Flight Mechanics Panel Specialists' Meeting on Piloted Aircraft Environment Simulation Techniques
Conference Location: Brussels, Belgium
Publisher: Advisory Group for Aerospace Research and Development (AGARD)
Date: April 24-27
Author's Title and Affiliation: Aeromechanics Laboratory, U.S. Army Aviation R&D Command, Ames Research Center, Moffett Field, CA 94035
Number of Pages: 17
Keywords: rotorcraft, vertical motion system, turbulence, ground effect, motion requirements, visual requirements
Notes: The rich and varied detail visible in terrain flight must be presented by a wide field-of-view system with much detail and high resolution. The rotary-wing R and D simulator must have great versatility for easy change of cab configurations and the capability to accommodate a two or three man crew. Basic specifications for an adequate visual display were developed and are compared with current and forecasted techniques for image generation and presentation. Results of a study performed to determine the feasibility of meeting these requirements using the current technology of TV camera-model image generation and projected display are discussed and an assessment of the possibility that computer generated imagery can achieve the desired level of detail is presented.

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Reference Type: Conference Proceedings
Author: Kiefer, Dennis A; Calvert, Jeffrey F.
Year of Conference: 1992
Title: Developmental evaluation of a centrifuge flight simulator as an enhanced maneuverability flying qualities tool
Conference Name: AIAA Flight Simulation Technologies Conference
Conference Location: Hilton Head Island, SC

Publisher: American Institute of Aeronautics and Astronautics (AIAA)
Pages: 191-212
Date: August 24-26
Electronic Resource Number: AIAA-92-4157-CP
Author's Title and Affiliation: Air Vehicle and Crew Systems Technology Department, Naval Air Warfare Center, Aircraft Division, Warminster, PA
Number of Pages: 22
Keywords: centrifuge flight simulator, flying qualities tool, dynamic flight simulator, ground-based, enhanced maneuverability, light weight cockpit, g-bias function, motion fidelity
Abstract: Significant improvements in high angle of attack aerodynamics, flight control systems and the use of thrust vectoring is providing current and anticipated aircraft with enhanced maneuverability. These aircraft generate unusual rates and accelerations which will severely affect pilot spatial orientation and situational awareness during air combat maneuvering. The developing technology of centrifuge flight simulation offers the prospect of ground-based flying qualities and human factors testing in this same environment.
Centrifuge flight simulation technology, as implemented on the Dynamic Flight Simulator, has shown its value with F-14 flat spin and mishap investigations, preliminary enhanced fighter maneuverability studies, and physiological investigations in a realistic flight environment. Recent and current efforts are to expand this role for potential use as an enhanced maneuverability simulation tool. Specifically targeted for evaluation is the ability to perform piloted analyses of critical displays during high angle of attack enhanced maneuvering tasks.
Improvements have been made to the Dynamic Flight Simulator motion base control and actuator quality, cockpit displays, data collection capability, and compatible tactical aircraft models. The evaluation involved analyzing improvements to motion fidelity and demonstrating the potential for addressing a broader class of aircraft research, development, test and evaluation issues. Limitations are separated into those inherent to the technology and those dependent on the Dynamic Flight Simulator implementation. Tradeoffs between control method and mission applications are shown.

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Reference Type: Journal Article
Author: Killgore, James I.
Year: 1989
Title: The planes that never leave the ground
Journal: American Heritage of Invention and Technology
Volume: 4
Issue: 3
Pages: 56-63
Number of Pages: 8

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Reference Type: Journal Article
Author: King, Raymond E.; Manning, Carol A.; Drechsler, Gena K.
Year: 2006
Title: Operational use of the air traffic selection and training battery
Journal: International Journal of Applied Aviation Studies
Volume: 6
Issue: 2
Pages: 207-218
Number of Pages: 13
Keywords: adverse impact, aptitude testing, computerized testing, personnel selection
Abstract: The Federal Aviation Administration (FAA) is commencing a massive hiring of air traffic control specialists using a new selection procedure, the Air Traffic Selection and Training (AT-SAT) computerized test battery. Before AT-SAT could be used for hiring purposes, however, the issue of its potential for adverse impact (potential unfair discrimination) had to be addressed. A previous project (Wise,

Tsacoumis, Waugh, Putka, & Hom, 2001) reweighted the subtests and adjusted the overall constant to mitigate potential group differences that could result in adverse impact, without unduly compromising validity. A subsequent study (Dattel & King, 2006) used research participants and found that this effort appeared to have achieved its goal of mitigating group differences that could result in adverse impact. The present study endeavors to: 1) describe how AT-SAT functions as an operational selection method with respect to the several applicant pools, and 2) determine how the reweighting effort fares with actual applicants in the goal of reducing/eliminating group differences that could result in adverse impact. Of the 854 applicants who have taken AT-SAT as part of a job application process (rather than as according to a research protocol), 219 applicants (25.64%) voluntarily disclosed their race; gender was known for 253 (29.63%). The results suggest that the reweighting effort is paying dividends as group differences that could result in adverse impact are not in evidence. While the initial numbers reported here are relatively small, the issue of group differences that could result in adverse impact will be continually monitored. Longitudinal validation, comparing AT-SAT results to training and on-the-job performance, is a research priority due to concerns about the overall passing rate of 93.33%, which is higher than the expected passing rate of 67%.

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Reference Type: Report
Author: Kingston, Paul; Peters, Tom; Lehman, Chris; Boothe, Edward M.; Gibb, Gerald D.; Hampton, Steven; Wise, John A.; Wolf, John
Year: 1992
Title: The real training value of FTDs in an airline training program
Author's Title and Affiliation: Kingston: IVEX
Peters: Captain, Delta Airlines
Lehman: Atlantis Aerospace Corporation
Boothe: Consultant, Flight Simulation and Training
Gibb, Hampton, Wise, Wolf: Embry-Riddle Aeronautical University
Number of Pages: 8
Keywords: flight training devices, FTD, air carriers
Abstract: The use of Flight Training Devices (FTD) in air carrier and other approved training programs has not become widespread. Most air carrier operators still prefer simulator programs using Level C or D simulators. An analysis has indicated that the most cost effective program would utilize an FTD for a significant portion of a conventional airline training program. A demonstration project to validate the conclusion of the analysis was conducted at the Delta Air Lines Training Center. Groups of pilots from Delta Air Lines and from Embry-Riddle Aeronautical University were trained using both the conventional all simulator curriculum and a curriculum in which a Level 6 FTD with a visual system was substituted for a significant portion of the training. Performance measures were obtained using simulator generated data, evaluations conducted by Aircrew Program Designees (APDs) and independent check pilots from Embry-Riddle. The results from standard type-rating check rides indicate that comparatively few significant differences still exist between the two training curricula. The results indicate that FTDs properly integrated with a simulator in an approved training program can produce pilot performance similar to those obtained from an all-simulator program. Further efforts should be expended to investigate assignment of training tasks to the appropriate level device. Since the initial and operating costs of a full flight simulator are significantly higher than that of an FTD, these efforts would be warranted.

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Reference Type: Journal Article
Author: Klauer, Ken M.
Year: 1997
Title: Examining the concept of total fidelity flight simulation
Journal: CSERIAC Gateway
Volume: 8
Issue: 2
Pages: 13 -15

Reference Type: Journal Article
Author: Klein, R. M.; Posner, M. I.
Year: 1974
Title: Attention to visual and kinesthetic components of skills
Journal: Brain Research
Volume: 71
Pages: 401-411
Author's Title and Affiliation: University of Oregon, Psychology Department
Number of Pages: 12
Abstract: The performance of skilled movements gives rise to several sources of feedback. It is important to determine whether and at what level these cues are used. This article considers their use at the highest level of conscious control. Several experimental techniques are outlined to investigate the role of attention on the processing of visual and kinesthetic cues during the acquisition, initiation, and control of movements.
The mere presence of a visual pattern disrupts the acquisition, initiation and control of a kinesthetic pattern, while the presence of a kinesthetic pattern does not affect the acquisition of a visual pattern unless the subject is forced to attend the kinesthetic information. In the acquisition of simple movements, kinesthetic cues seem to be ignored when visual cues are present, even though this delays initiation. These results support the view that vision dominates kinesthesis at the level of central attention. Attentional mechanisms are involved in the initiation and control of discreet movements. Within the context of a continuous tracking task anticipated corrections appear to demand more attention than those which are not anticipated.

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Reference Type: Journal Article
Author: Kleiss, James
Year: 1995
Title: Visual scene properties relevant for simulating low-altitude flight: A Multidimensional scaling approach
Journal: Human Factors
Volume: 37
Issue: 4
Pages: 711-734
Author's Title and Affiliation: University of Dayton Research Institute, Dayton, OH
Number of Pages: 24
Abstract: In the present experiments I sought to identify the properties of visual scenes relevant for simulating low-altitude flight. The approach was first to identify the relevant properties of real-world scenes. The stimuli were videotape segments or still photographs of real-world scenes exhibiting a variety of scene properties. Ratings of similarity between stimulus pairs were submitted to multidimensional scaling analyses. Results using videotape segments provided consistent evidence for two relevant scene properties: variation in terrain shape and variation in object size or spacing. Results using still photographs were less interpretable, supporting the argument that motion information is important. Results suggest that designers of flight simulator visual scenes should focus specifically on rendering elements of terrain shape and objects in scenes.

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Reference Type: Journal Article
Author: Kleiss, James A.; Hubbard, David C.
Year: 1993
Title: Effects of three types of flight simulator visual scene detail on detection of altitude change
Journal: Human Factors
Volume: 35
Issue: 4
Pages: 653-671

Date: December
Author's Title and Affiliation: Kleiss & Hubbard: University of Dayton Research Institute
Number of Pages: 19
Abstract: The effects of three types of flight simulator visual scene detail on detection of altitude change were evaluated in three experiments. Across all experiments and with a variety of tasks and display conditions, speed and accuracy of detecting altitude change improved with increases in the density of vertical objects in scenes. Adding detail to individual objects to increase their natural appearance produced no consistent effects on performance. In experiment 3 complex texture distributed globally on terrain surfaces improved detection of altitude change but did not alleviate the need for high object density. These results indicate that available computer image generator processing capacity would be used more effectively by increasing the density of objects in scenes, rather than by increases in the complexity and detail of individual objects. Complex texture is used more effectively when distributed globally on terrain surfaces, rather than when allocated to individual objects.

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Reference Type: Book
Author: Kline, R. B.
Year: 2004
Title: Beyond significance testing: Reforming data analysis methods in behavioral research
City: Washington, DC
Publisher: American Psychological Association (APA)
Number of Pages: 325
Author's Title and Affiliation: Associate Professor of Psychology, Concordia University, Montreal, Canada

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Reference Type: Report
Author: Klyde, D. H.; Mitchell, D. G.
Year: 1997
Title: Handling qualities demonstration maneuvers for fixed wing aircraft Vol. I: Maneuver development process
City: Hawthorne, CA
Institution: Systems Technology, Inc.
Pages: 1-193
Date: September
Type: Technical Report
Report Number: 1310-1
Author's Title and Affiliation: David H. Klyde: Systems Technology, Inc.
David G. Mitchell: Hoh Aeronautics, Inc.
Keywords: handling qualities, upset recovery training (URT)
Abstract: I. INTRODUCTION
This report documents the results of a Phase II Small Business Innovation Research (SBIR) contract to develop and evaluate a set of demonstration maneuvers for the evaluation of fixed wing aircraft handling qualities. Systems Technology, Inc. (STI) and principle subcontractor Hoh Aeronautics, Inc. (HAI) conducted the work for the Air Force Dynamics Directorate at Wright Laboratory. The significant aircraft handling qualities research of the past 25 to 30 years was reviewed and relevant flight test maneuvers were compiled and categorized. By applying a mission-oriented approach, the maneuvers were categorized by required levels of precision and aggressiveness. A preliminary demonstration maneuver set was assembled with existing, refined, and newly defined maneuvers. Flight test evaluations with experienced test pilots were then used to verify that a maneuver could be flown as intended, to revise maneuver descriptions and handling qualities performance requirements, and to assess operational relevance. Some maneuver evaluations were also conducted with ground-based simulators when relevant flight test opportunities did not exist. The results of these evaluations were used to assemble a final maneuver catalog. Maneuvers that were found to emphasize aircraft performance rather than

handling qualities were removed from the final set. The resulting catalog is referred to as "final" only in relation to this research effort. Following in the footsteps of previous aircraft handling qualities research, the maneuver catalog is considered a living document and therefore further revisions and additions are expected as new research is conducted.

The overall program objective was to develop a catalog of demonstration maneuvers that may be used to evaluate:

-All aircraft types (military and civil) and mission tasks;

-Modern flight control systems;

-The effect of advanced displays and vision aids on handling qualities; and

-Multiple-axis handling qualities.

The maneuvers will provide a check of handling qualities beyond the quantitative criteria of the military flying qualities standard, MIL-STD-1797 (Ref. 1). A primary benefit of a formalized set of repeatable, measurable, and well-constrained demonstration maneuvers is that they may be used from the initial design stages to post-developmental testing of an aircraft. Because the demonstration maneuvers are mission-oriented, they provide an essential link between operational requirements and the design process. Background material is provided in Part II.

The first step of this program was to define a catalog of proposed demonstration maneuvers. During the SBIR Phase I effort (Appendix C of Ref. 2), potential maneuvers were identified from an extensive literature search of relevant handling qualities flight test and simulator evaluations. This effort along with the development of numerous new maneuvers was continued as the initial Phase II task. This process is documented in Part III.

The next step of this program was to evaluate as many of the maneuvers as possible in a flight test environment. Funding was provided by the USAF to evaluate the Standard Evaluation Maneuver Set (STEMS) on the NASA F/A-18 High Alpha Research Vehicle (HARV) as part of this program. McDonnell Douglass Aerospace had previously developed the STEMS (Ref. 3) for the USAF Flight Dynamics Directorate through piloted simulation. Details of the two-phase HARV flight test program are published in Ref. 4 and summarized herein. Unfortunately, further direct funding for flight test of other demonstration maneuvers was not available. Thus, efforts were made to evaluate additional maneuvers as part of existing USAF, NASA, and United States Navy (USN) flight test programs. In the end, 18 maneuvers of the 36 present in the final version of the maneuver catalog were evaluated in flight. Additional maneuver evaluations were conducted via piloted simulation. The results of these evaluations are presented in Part IV, while details of the individual flight test and simulator programs are provided in the appendices to this report.

The last step was to assemble the revised maneuvers into a final version of the maneuver catalog (Part V of this report). The authors, of course, anticipate and encourage refinements and additions to the catalog as new research is conducted. To facilitate the use of the catalog, Part V has been published as a separate report volume.

This volume of the report concludes in Part VI with a program summary and recommendations for further research.

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Reference Type: Report
Author: Klyde, D. H.; Mitchell, D. G.
Year: 1997
Title: Handling qualities demonstration maneuvers for fixed wing aircraft Vol. II: Maneuver catalog
City: Hawthorne, CA
Institution: Systems Technology, Inc.
Pages: 1-95
Date: September
Type: Technical Report
Report Number: 1310-1
Author's Title and Affiliation: David H. Klyde: Systems Technology, Inc.
David G. Mitchell: Hoh Aeronautics, Inc.
Keywords: handling qualities, upset recovery training (URT)
Abstract: (A. Introduction)

This report documents the results of a Phase II Small Business Innovation Research (SBIR) contract to develop and evaluate a set of demonstration maneuvers for the evaluation of fixed wing aircraft handling qualities. Systems Technology, Inc. (STI) and principle subcontractor Hoh Aeronautics, Inc. (HAI) conducted the work for the Air Force Dynamics Directorate at Wright Laboratory. The significant aircraft handling qualities research of the past 25 to 30 years was reviewed and relevant flight test maneuvers were compiled and categorized. By applying a mission-oriented approach, the maneuvers were categorized by required levels of precision and aggressiveness. A preliminary demonstration maneuver set was assembled with existing, refined, and newly defined maneuvers. Flight test evaluations with experienced test pilots were then used to verify that a maneuver could be flown as intended, to revise maneuver descriptions and handling qualities performance requirements, and to assess operational relevance. Some maneuver evaluations were also conducted with ground-based simulators when relevant flight test opportunities did not exist. The results of these evaluations were used to assemble a final maneuver catalog. Maneuvers that were found to emphasize aircraft performance rather than handling qualities were removed from the final set. The resulting catalog is referred to as "final" only in relation to this research effort. Following in the footsteps of previous aircraft handling qualities research, the maneuver catalog is considered a living document and therefore further revisions and additions are expected as new research is conducted.

The overall program objective was to develop a catalog of demonstration maneuvers that may be used to evaluate:

-All aircraft types (military and civil) and mission tasks;
-Modern flight control systems;
-The effect of advanced displays and vision aids on handling qualities; and
-Multiple-axis handling qualities.

In addition the maneuvers will provide a check of handling qualities beyond the quantitative criteria of the military flying qualities standard, MIL-STD-1797A (Ref. 1). A primary benefit of a formalized set of repeatable, measurable, and well-constrained demonstration maneuvers is that they may be used from the initial design stages to post-developmental testing of an aircraft. Because the demonstration maneuvers are mission-oriented, they provide an essential link between operational requirements and the design process. Volume I of this report provides relevant background material, a discussion of the issues influencing the development of candidate maneuvers, results of specific flight test and piloted simulation evaluations, and a program summary and recommendations.

This report volume presents a set of handling qualities demonstration maneuvers that were developed to be included in a future revision to MIL-STD-1797A. These are *handling qualities* evaluation maneuvers, and are not intended to dictate aircraft performance. Rather they should be adjusted to include the full performance range of the aircraft. They are also not specifically aimed toward assessment of susceptibility to pilot-induced oscillations (PIO); other work is currently ongoing for this purpose. This is why the familiar Handling Qualities During Tracking (HQDT) task, for example, that requires the pilot to track a target as tightly as possible, is not included. Other air-to-air tracking tasks with defined performance requirements, however, are included in this set of maneuvers.

The desired and adequate performance requirements of the demonstration maneuvers catalog presented herein were developed specifically for use with the familiar Cooper-Harper Handling Qualities Rating Scale (Ref. 2). In addition, the maneuvers were assembled with the expectation that PIO ratings would also be taken, or at the least PIO susceptibility would be included in the pilot evaluation process. For this reason explicit desired and adequate performance requirements regarding PIO and "bobble" were not included in the maneuver descriptions. The susceptibility of an aircraft configuration to undesired or divergent oscillations should, therefore, be considered implicit requirements and always be accounted for in the pilot's ratings and comments.

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Reference Type: Conference Proceedings
Author: Knotts, Louis H.; Bailey, Randall E.
Year of Conference: 1988
Title: Ground simulator requirements based on in-flight simulation
Conference Name: AIAA Flight Simulation Technologies Conference
Conference Location: Atlanta, GA
Publisher: American Institute of Aeronautics and Astronautics (AIAA)
Pages: 191-197
Date: September 7-9
Electronic Resource Number: AIAA 88-4609-CP
Author's Title and Affiliation: Knotts: Principal Engineer, Member AIAA, Calspan Advanced Technology Center, Buffalo, NY
Bailey: Senior Engineer, Calspan Advanced Technology Center, Buffalo, NY
Number of Pages: 7
Keywords: ground simulator requirements, in-flight simulation, NT-33A, piloting tasking, pilot-induced oscillations, time delays, upset recovery training (URT)
Abstract: Several recent NT-33A in-flight simulation projects have addressed issues relevant to ground simulator fidelity. During two of these studies a comparison was made of handling qualities for several aircraft configurations when flown in the NT-33A compared to the same configurations flown in a ground simulator. Piloting tasks consisted of visual landings and head-up display tracking tasks. During one of these studies systematic variation of added time delay was made for several generic types of aircraft in the flight as well as the ground simulator environment. Observations were made concerning the effects of piloting task, simulator motion, and time delay on aircraft handling qualities. A third study consisted of an in-flight investigation into the effects of feel system dynamics and time delay on lateral handling qualities. It was found that low frequency artificial feel systems can significantly degrade handling qualities. The findings of this study can be applied to control loader requirements for ground simulators. A common theme of the generic simulation studies performed in the NT-33A is that calibration and documentation is an essential step in the set-up of a simulation. This is true not only for simulation of aircraft dynamics, but also for other characteristics which may affect handling qualities such as time delay and control stick characteristics.

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Reference Type: Report
Author: Kochan, Janeen A.; Moskal, Michael
Year: 2006
Title: Upset recovery training program: Interim report on training effectiveness
City: Roswell, NM
Institution: CUBRC Flight Research Center
Date: April
Report Number: NM03MMT-04
Author's Title and Affiliation: CUBRC Flight Reseach Training Center, Eastern New Mexico University - Roswell
Recipient's Title and Affiliation: New Mexico Department of Transportation Research Bureau, Albuquerque, NM
Number of Pages: 54
Keywords: upset recovery training (URT), flight training, in-flight simulation, human factors
Abstract: Loss-of-control in flight was the largest category of fatal commercial air carrier accidents between 1994 and 2003 (Boeing Commercial Airplanes Group, 2004). Thirty-two out of the 105 fatal accidents resulted in 2,670 deaths. Loss-of-control accidents were also the second leading cause of general aviation accidents in the United States and have been on the constant increase for all categories of flight for the past 25 years. The Flight Research Training Center, established in 2002, by the Alliance for Flight Safety Research in cooperation with the Federal Aviation Administration, provides specific training for pilots on dealing with upset events that can lead to loss-of-control. This document describes the methods for the collection of pilot performance data which was performed under the FAA funded Upset Recovery Training program for the period from August 8, 2002 through November 18, 2005. The

report also details the results of the analysis of the collected data which was separately funded by NMDOT beginning March 2005.
URL: http://www.nmshtd.state.nm.us/upload/images/Research/reports05/NM03MMT-04Upset_Recovery_Training.pdf
Author Address: CUBRC Flight Research Training Center, Eastern New Mexico University - Roswell, PO Box 6000, Roswell, NM 88203

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Reference Type: Conference Paper
Author: Kochan, Janeen A.; Priest, James E.; Moskal, Mike
Year: 2005
Title: Human factors of upset recovery training
Conference Name: 17th Annual European Aviation Safety Seminar
Conference Location: Warsaw, Poland
Publisher: Flight Safety Foundation
European Regions Airline Association
Date: March 14-16
Author's Title and Affiliation: Kochan and Moskal: Calspan-UB Research Center, Inc.
Priest: Calspan
Keywords: loss-of-control, unexpected events, upset recovery training (URT)
Abstract: Loss-of-control in flight was the largest category of fatal U.S. commercial air carrier accidents between 1994 and 2003. Loss-of-control accidents were also the leading cause of general aviation accidents in the U.S. in 2003 and these accidents have been on the constant increase for all categories of flight in the U.S. for the past 25 years. Statistics from aviation accidents and incidents from around the world echo the same theme. In response to this issue, the Flight Research Training Center was established in 2002, in cooperation with the U.S. Federal Aviation Administration, to provide specific training for pilots dealing with "upset events" that could lead to loss-of-control. This multi-faceted Upset Recovery Training (URT) program includes other types of aircraft. This paper will discuss (a) a model representing the cognitive process of surprise, (b) how an unexpected event can escalate to a loss-of-control situation, and (c) an upset recovery training program which addresses specific aspects of the model critical to a pilot's successful response to an unexpected event. Relevant loss-of-control accidents from around the world will be reviewed and practical applications of upset recovery techniques will be presented with a focus on human factors aspects of the unexpected.

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Reference Type: Magazine Article
Author: Kocks, Kathleen
Year: 1998
Title: Training overview: Filling the 'qualifications gap'
Magazine: Aviation Today
Volume: December
Date: December
Number of Pages: 12
Abstract: Rotor & Wing's recent polling of the helicopter training industry reveals progress in training new commercial pilots, but some disturbing trends suggest that the industry faces serious challenges.

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Reference Type: Report
Author: Kolasinski, E. M.
Year: 1998
Title: Prediction of simulator sickness in a virtual environment
Number of Pages: 5
URL: http://www.hitl.washington.edu/research/knowledge_base/virtual-worlds/kolasinski/

Reference Type: Report
Author: Kolasinski, Eugenia M.; Goldberg, Stephen L.; Hiller, Jack H.
Year: 1995
Title: Simulator sickness in virtual environments
City: Alexandria, VA
Institution: United States Army Research Institute for the Behavioral and Social Sciences
Date: May
Type: Technical Report
Report Number: Technical Report 1027
Author's Title and Affiliation: Kolasinski: U.S. Army Research Institute
Goldberg: Chief, Simulator Systems Research Unit
Hiller: Director, Training Systems Research Division
Recipient's Title and Affiliation: U.S. Army Research Institute for the Behavioral and Social Sciences, 5001 Eisenhower Avenue, Alexandria, VA 22333-5600
Number of Pages: 48
Abstract: <u>Requirement</u>
The Army has made a substantial commitment to Distributed Interactive Simulation (DIS) and the electronic battlefield for training, concept development, and test and evaluation. The current DIS training system--Simulation Networking (SIMNET)--and the next generation system--the Close Combat Tactical Trainer (CCTT)--provide effective training for soldiers fighting from vehicles, but are unable to do the same for individual dismounted soldiers. Virtual Environment (VE) technology has the potential to provide Individual Combat Simulations (ICS) for the electronic battlefield. However, initial research in the use of VE technology indicates that some participants experience simulator sickness--a pattern of symptoms including nausea, headaches, and disorientation. This has implications for both training effectiveness and safety. This report is the first step in the identification of ways to reduce the occurrence and severity of these symptoms.
<u>Procedure</u>
Since the research literature of simulator sickness in VEs is very limited, the literature on sickness in other types of simulators and, to a lesser extent, the literature on the related phenomenon of motion sickness were reviewed. The factors believed to affect the duration and severity of simulator sickness were organized into three groups: simulator factors, task factors, and individual factors.
<u>Findings</u>
Although there is debate as to the exact cause or causes of simulator sickness, a primary suspected cause is inconsistent information about body orientation and motion received by the different senses, known as the cue conflict theory. For example, the visual system may perceive that the body is moving rapidly, while the vestibular system perceives that the body is stationary. Inconsistent, non-natural information within a single sense has also been prominent among suggested causes.
Although a large contingent of researchers believe the cue conflict theory explains simulator sickness, an alternative theory was reviewed as well. Forty factors shown or believed to influence the occurrence or severity of simulator sickness were identified. Future research is proposed.
<u>Utilization of Findings</u>
This literature search provides a framework that can be used to conduct future research to reduce the occurrence of simulator sickness in virtual environments. In addition, it has directly influenced the approach being used in technical advisory service provided to Headquarters, U.S. Army Training and Doctrine Command, to reduce simulator sickness in combat vehicle trainers.
URL: http://stinet.dtic.mil/cgi-bin/GetTRDoc?AD=ADA295861&Location=U2&doc=GetTRDoc.pdf

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Reference Type: Conference Paper
Author: Komoda, Masaki; Kawahata, Nagakatsu; Tsukano, Yukichi; Ono, Takatsugu
Year: 1988
Title: VSRA In-flight simulator--Its evaluation and applications
Conference Name: AIAA Flight Simulation Technologies Conference
Conference Location: Atlanta, GA
Publisher: American Institute of Aeronautics and Astronautics (AIAA)

Date: September 7-9
Electronic Resource Number: AIAA-1988-4605
Author's Title and Affiliation: Komoda: Tokyo Metropolitan Institute of Technology, Tokyo, Japan
Kawahata: Nihon University, Chiba, Japan
Tsukano and Ono: National Aerospace Laboratory, Tokyo, Japan
Number of Pages: 11
Abstract: The paper describes an in-flight simulator named VSRA (Variable Stability and Response Airplane), in some detail. The VSRA system is designed based upon an explicit model following theory. Only linearized dynamics are assumed. Discussed are technical difficulties which are pertinent to the VSRA systems and have been overcome to achieve good model following capabilities. Two examples of VSRA's application to studying problems concerning to man-machine dynamic systems are included to show that the VSRA is a mandatory device to some classes of flight mechanical problems. The one is related to evaluating a newly proposed mode-decoupling (named Relaxed Static and Speed Stability - RSS^2) system, and the other is to investigate pilot's capability for detecting failures in control systems assuming an aircraft accident.

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Reference Type: Report
Author: Koonce, J. M.
Year: 1974
Title: Effects of ground-based aircraft simulator motion conditions upon prediction of pilot proficiency. Part II
City: Savoy, Illinois
Institution: University of Illinois
Date: April
Report Number: AFOSR-TR-74-1292
Author's Title and Affiliation: University of Illinois, Savoy, IL
Number of Pages: 213
Keywords: performance prediction, pilot training, flight simulator motion
Abstract: Three groups of thirty pilots with multi-engine and instrument ratings performed a simulated flight mission in a General Aviation Trainer - 2 (GAT-2) on each of two days. The experimental conditions for the groups differed in terms of GAT-2 motion (Group I--no motion; Group II--sustained linear, scaled-down analog motion; Group III--washout motion). Each group of pilots then flew the same mission in a light twin-engine aircraft representative of the class of aircraft simulated by the GAT-2. The experimental design was a two factor mixed design (groups by days) with repeated measures on one factor (groups). The mission consisted of five maneuvers representative of those usually performed under instrument flight rules (IFR) without visual reference to the outside world and five maneuvers usually performed with outside visual contact under visual flight rules (VFR). In the simulator, all of the maneuvers were performed without outside visual reference.
Two trained observers, one of whom was also the safety pilot for the mission, recorded pilot performance on each mission in a specially designed booklet. The order of assignment of observers to the mission permitted recording of a pilot’s performance on two successive missions by the same observer and two independent observers.
The results indicated that the proficiency of aircraft pilots can be predicted to a high degree from ground-based simulator performance measures. Of the three simulator motion conditions used greater prediction of operator performance from a simulator to flight can be obtained using sustained cockpit motion than by using washout motion or no motion. There was no significant difference between the predictive validities of performance with no motion and washout motion.
The experiment demonstrated that very high observer-observer reliabilities (r = .771 to .971) on the same mission can be obtained by recording performance on scales that are well defined and easy to follow, descriptive of the maneuver and behavior being recorded, and not too demanding upon the person doing the recording of performance. The performance measures taken in the simulator tended to be more reliable than those taken in the aircraft because of the elimination of degrading environmental factors and the reduction of safety oriented duties frequently imposed upon safety observers.

Simulator motion tends to increase subject acceptability of the device, lower performance error scores, and reduce the workload on the subjects and observers through the aiding effects of the motion onset cues. But the differential effects of motion on two performance trials in the simulator do not transfer to performance in flight. In the prediction of operator performance in flight the magnitude of the error scores resulting with the use of one motion system as opposed to another is not as important as the stability of the subjects' performances from one day to the next. Increasing the fidelity of the simulator motion system may bring much of the variability of flight into the simulated environment which was used to escape the variability of the operational environment.
The recorded pilot performance measures correlated very highly with the observers' overall subjective ratings of the missions (r = .726 to .878). The observers' overall ratings correlated slightly higher with performance on instrument flight maneuvers than with performance on visual flight maneuvers. Other possible indices of pilot proficiency, such as the amount of multi-engine land, instrument or total flight time logged in the past six months, did not correlate very well with mission performance scores, in fact they correlated about as well as age.

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Reference Type: Journal Article
Author: Koonce, Jefferson M.; Bramble, William J., Jr.
Year: 1998
Title: Personal computer-based flight training devices
Journal: International Journal of Aviation Psychology (IJAP)
Volume: 8
Issue: 3
Pages: 277-292
Author's Title and Affiliation: Koonce: University of Central Florida, Center for Applied Human Factors in Aviation, Orlando
Bramble: Flight Safety International, Daytona Beach, Florida
Number of Pages: 16
Keywords: personal computer aviation training devices (PCATDs), aviation pilot training, flight simulator development, simulator training, fidelity
Abstract: This article reviews the role of personal computer aviation training devices in general aviation pilot training. A brief history of flight simulator development is provided, accompanied by a sampling of early research on the effectiveness of simulator training. PCATDs are described along with their more common interface devices. Next, an examination of the use of PC-based flight simulators in formal and informal flight training programs reveals some of the recent data validating their use. Special emphasis is paid to the use of PC-based flight simulators for the instruction of novices in how to fly and the training of pilots in the performance of instrument flight maneuvers. Then, the role fidelity plays in producing transfer from PC-based training devices is addressed. Finally, a case is made for researchers to provide the kind of data that regulatory agencies should use in determining the standards for certification of PCATDs in flight training programs. Finally, suggestions are made for improvement of future PC-based flight training devices.

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Reference Type: Conference Paper
Author: Korn, Jonathan; Kleinman, David L.
Year: 1982
Title: Modeling lateral acceleration effects on pilot performance
Conference Name: Ames Research Center 16th Annual Conference on Manual Control
Conference Location: Storrs, CT
Publisher: University of Connecticut, Department of Electrical Engineering and Computer Science
Author's Title and Affiliation: University of Connecticut, Department of Electrical Engineering and Computer Science, Storrs, CT 06268
Number of Pages: 9

Abstract: Attendant to the direct side force maneuver of a Vectored Force Fighter is the transverse acceleration imposed on the pilot. This lateral acceleration(Gy), when combined with a positive Gz stress, is a potential source of pilot tracking performance impairment. A research effort to investigate these performance decrements includes experimental as well as analytical pilot performance modeling using the Optimal Control Model.

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Reference Type: Report
Author: Korteling, J. E.; Sluimer, R. R.
Year: 1999
Title: A critical review of validation methods for the man-in-the-loop simulators
Institution: TNO Human Factors Research Institute
Pages: 1-31
Date: March 16
Type: TNO-report
Report Number: TNO-report TM-99-A023
Author's Title and Affiliation: TNO Human Factors Research Institute, Kampweg 5, 3769 DE Soesterberg
Number of Pages: 32
Abstract: This review examines the methodological concepts, paradigms and pitfalls related to validation- and fidelity studies of man-in-the-loop simulators. A distinction is made between validation methods for training simulators and for research simulators. Validation methods for training simulators are applied in experiments which assess effects of simulator variables (e.g. resolution of display, cue augmentation, moving base characteristics) on the effectiveness of a simulator as a training device. Validation methods for research simulators are applied in experiments which assess the effects of simulator variables on the effectiveness of a simulator as a research tool. The review is particularly focused on the various artifact that may affect the outcome of such validation experiments. The artifact are separately described for each single validation method. It will be demonstrate that validation of simulators is a very complicated matter and prone to various methodological flaws and confounding factors. After the discussion of the common methods including their advantages and disadvantages the following recommendations for future research are given:
1. Terminology in the field of simulator research is ambiguous. It is advised to standardize terms, which will lead to more comprehensible communication among researchers.
2. Validity is not a single, independent attribute. The term validity in simulator research only makes sense if related to functional aspects of simulators, such as the purpose of the simulator (training, research) and the tasks and training methods involved. This will reduce the amount of overgeneralizations that are now encountered too frequently.
3. Always take face validity into consideration. If people do not believe in the simulator they are not very likely to use it properly.
4. Apply more than one method in simulator validity study. Combination of e.g. objective with subjective methods reduces the risk of erroneous conclusions and combines the benefits of both kinds of methods.
5. Aim more research at creating task-specific formulas, which relate physical simulator variables to psycho-physical and human performance variables. This will reduce the need to measure human task performance in simulator validation studies.
6. Always allocate substantial effort to find a practical method that still compares simulator performance with on-the-job performance by subjects. A relatively simple and practical method is proposed to assess the effectiveness of a driving simulator training.

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Reference Type: Journal Article
Author: Kozac, J. J.; Hancock, P. A. ; Arthur, E. J.; Chrysler, S. T.
Year: 1993
Title: Transfer of training from virtual reality
Journal: Ergonomics
Volume: 36
Pages: 777-784

*****

Reference Type: Conference Paper
Author: Kraft, Conrad L.; Shaffer, Larry W.
Year: 1978
Title: Visual criteria for out of the cockpit visual scenes
Conference Name: Flight Mechanics Panel Specialists' Meeting on Piloted Aircraft Environment Simulation Techniques
Conference Location: Brussels, Belgium
Publisher: Advisory Group for Aerospace Research and Development (AGARD)
Date: April 24-27
Author's Title and Affiliation: Kraft: Ph.D., Crew Systems, Boeing Aerospace Company, Seattle, WA
Shaffer: Systems Engineering, General Electric Company, Daytona Beach, FL
Number of Pages: 18
Keywords: visual resolution, cockpit visual scenes, field of view, virtual image display

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Reference Type: Conference Paper
Author: Kricke, K. Dieter; Quellmann, Wilfried
Year: 1991
Title: Use of a virtual cockpit for the development of a future transport aircraft
Conference Name: Flight Mechanics Panel Symposium on Flight Simulation Effectiveness
Conference Location: Brussels, Belgium
Publisher: Advisory Group for Aerospace Research and Development (AGARD)
Date: October 14
Author's Title and Affiliation: Kricke: Dr-Ing., Deutsche Airbus, Kreetslag 10, P O Box 95 01 09, 2103 Hamburg 95, Germany
Quellmann: Dipl.-Ing., Deutsche Airbus, Kreetslag 10, P O Box 95 01 09, 2103 Hamburg 95, Germany
Number of Pages: 10
Keywords: virtual cockpit, transport aircraft
Abstract: This paper describes a development tool called "Virtual Cockpit" which is used at Deutsche Airbus.
The following aspects are discussed:
A comparison of civil and military transport aircraft developments shows a significant gap on the military tactical transport side during the last 30 years. Therefore, it seems beneficial to consider a "dual use" of well proven "civil technologies" for military applications.
Specific military transport missions require aircraft capabilities, some of which are quite new and therefore challenging for transport aircraft (e.g. low-level flight profiles in night and poor-visibility conditions). This demonstration of the feasibility and an evaluation of technical solutions imply the need for suitable development tools.
The Virtual Cockpit is explained in terms of its components (hardware/software), features and capabilities. A major field of investigation in this contest is the aircraft systems' central control and monitoring.
Notes: Published in February 1992.

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Reference Type: Conference Paper
Author: Krois, P.; Ahlstrom, U.; Bürki-Cohen, J.; Jentsch, F.; Kanki, B.G.; Lyall, B.; Manning, C.; King, R.
Year: 2006
Title: Business case for civil aviation human factors
Conference Name: Human Factors and Ergonomics Society 50th Annual Meeting
Conference Location: San Francisco, CA
Date: October 16-20
Author's Title and Affiliation: Panel Organizer: Paul Krois, Federal Aviation Administration, Washington, D.C.
Panelists: Ulf Ahlstrom, FAA Technical Center, Atlantic City Airport, NJ; Judith Bürki-Cohen, Volpe National Transportation Systems Center, Cambridge, MA; Florian Jentsch, University of Central Florida, Orlando, FL; Barbara Kanki, NASA Ames Research Center, Moffett Field, CA; Beth Lyall, Research Integrations, Inc., Tempe, AZ; Carol Manning and Ray King, FAA Civil Aerospace Medical Institute, Oklahoma City, OK
Abstract: We examined how human factors research and engineering in addressing flight deck and air traffic control issues improves safety and provides tangible cost savings and cost avoidance for Federal Aviation Administration sponsors and industry. The agency spends a limited percentage of its annual budget on research and prioritizes these investments to ensure the best return. This research cuts across a range of human factors considerations spanning selection of applicants for air traffic controller jobs, flight simulator fidelity, generation of scenarios used in pilot training, a new evaluation tool for flight deck certification, design of flight deck operating documents, and design of an air traffic controller information display aid.

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Reference Type: Conference Proceedings
Author: Kuge, Nobuyuki; Kutoba, Masanori; Itoh, Kazuya
Year of Conference: 2002
Title: A study on a motion algorithm based on a driver-centered approach
Conference Name: Driving Simulation Conference (DSC)
Conference Location: Paris, France
Date: September
Author's Title and Affiliation: Kuge: Vehicle Research Laboratory, Nissan Research Center, Nissan Motor Co., Ltd.
Kubota: Vehicle Dynamic Performance Test Group, Nissan Motor Co., Ltd.
Itoh: Body System Test Group, Nissan Motor Co., Ltd.
Abstract: The Nissan Driving Simulator, consisting of a six-axis platform and a large field-of-view screen installed on the floor, has the same general motion-rendering capabilities as other simulators in this category. It is important to apply an appropriate motion cueing strategy in order to enable the driver to perceive acceleration as closely as possible to that of an actual vehicle within the limitations of the system and in accordance with the given experimental scenario. This paper presents a study concerning a motion-rendering method based on a driver-centered approach. Focusing on braking situations, simulator experiments concerning longitudinal acceleration were carried out. Professional test drivers capable of evaluating vehicle dynamics accurately participated in the experiments as subjects and experienced a large number of braking scenes covering a wide range of deceleration levels and vehicle velocities. They evaluated combinations of parameters related to the motion algorithm such as the scale factor for reducing acceleration with respect to parallel movement in the transient domain of acceleration. These parameters were arranged in an orthogonal array in the method of design of [the] experiment. The results revealed the quantitative effectiveness of each parameter with regard to obtaining perceived deceleration close to that of an actual vehicle in braking situations.
Author Address: Kuge: Vehicle Research Laboratory, Nissan Research Center, Nissan Motor Co., Ltd., 1 Natsushima-cho Yokosuka 237-8523, Japan; Tel +81-468-67-5155, Fax +81-468-65-5699, n-kuge@mail.nissan.co.jp; Kubota: Vehicle Dynamic Performance Test Group, Nissan Motor Co., Ltd., 2250, Kamigamou, Kamiinokawa 329-0692, Japan; Tel +81-285-56-1409, Fax +81-285-56-1431, m-kbt@mail.nissan.co.jp; Itoh: Body System Test Group, Nissan Motor Co., Ltd., 560-2, Okatsukoku, Atsugi 243-0192, Japan; Tel +81-46-270-1396, Fax +81-46-270-1571, kazu-itoh@mail.nissan.co.jp

Reference Type: Conference Paper
Author: Kurts, David; Gainer, Charles
Year: 1991
Title: The use of a dedicated testbed to evaluate simulator training effectiveness
Conference Name: Flight Mechanics Panel Symposium on Piloted Simulation Effectiveness
Conference Location: Brussels, Belgium
Publisher: Advisory Group for Aerospace Research and Development (AGARD)
Date: October 14
Author's Title and Affiliation: Kurts: Manager, Tactical Systems, CAE Electronics Ltd., Montreal, Quebec, Canada; Gainer: Chief, Army Research Institute, Aviation Research and Development Activity, Fort Rucker, AL
Number of Pages: 9
Keywords: testbed, training effectiveness, SCTB, visual
Abstract: The Simulator Complexity Test Bed (SCTB) is being produced for the U.S. Army Research Institute Aviation Research and Development Activity (ARIARDA) at Fort Rucker, Alabama to specifically address the question of the level of simulation fidelity required to ensure adequate transfer of training in a tactical helicopter simulator environment. This paper presents the objectives of the SCTB, the hardware and software architecture designed to facilitate these goals and presents examples of some typical research that will be conducted. The simulator is based in the Apache AH-64A attack helicopter using aircraft parts and simulated avionics to provide a realistic replica of the pilot and copilot gunner stations.
Notes: Published in February 1992.

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Reference Type: Conference Proceedings
Author: Kwatny, Harry G.; Dongmo, Jean-Etienne T.; Chang, Bor-Chin; Bajpai, Gaurav; Yasar, Murat; Belcastro, Christine
Year of Conference: 2009
Title: Aircraft accident prevention: Loss-of-control analysis
Conference Name: AIAA Guidance, Navigation, and Control Conference
Conference Location: Chicago, IL
Publisher: American Institute of Aeronautics and Astronautics (AIAA)
Pages: 1-14
Date: Aug. 10-13
Electronic Resource Number: AIAA-2009-6256
Author's Title and Affiliation: Kwatny: S. Herbert Raynes Professor, Drexel University, Philadelphia, PA
Dongmo: Graduate Student, Drexel University, Philadelphia, PA
Chang: Professor, Drexel University, Philadelphia, PA
Bajpai: Director, Dynamics and Control, Techno-Sciences, Inc., Beltsville, MD
Yasar: Research Engineer, Techno-Sciences, Inc., Beltsville, MD
Belcastro: Senior Research Engineer, NASA Langley Research Center, Hampton, VA
Keywords: loss of control (LOC), nonlinear dynamics, upset recovery training (URT)
Abstract: The majority of fatal aircraft accidents are associated with 'loss-of-control.' Yet the notion of loss-of-control is not well-defined in terms suitable for rigorous control systems analysis. Loss-of-control is generally associated with flight outside of the normal flight envelope, with nonlinear influences, and with an inability of the pilot to control the aircraft. The two primary sources of nonlinearity are the intrinsic nonlinear dynamics of the aircraft and the state and control constraints within which the aircraft must operate. In this paper we examine how these nonlinearities affect the ability to control the aircraft and how they may contribute to loss-of-control. Examples are provided using NASA's Generic Transport Model.

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Reference Type: Web Page
Author: L-3 Communications' Link Simulation & Training Division
Year: 2006
Title: Link Simulation & Training: Setting the standard for over 75 years
Access Year: 2007
Access Date: July 9
Last Update Date: January 18, 2006
Keywords: Edwin Link, Link trainer, history
Abstract: In today's world of acquisitions and consolidations, organizational history can become blurred and sometimes forgotten. At L-3 Communications' Link Simulation & Training division, however, we point with pride to a heritage that dates back to several successful organizations that in recent years have been merged into one of the world's foremost training and simulation companies.
The Link name has been associated with training excellence for 75 years. Below are a few of the historical highlights of the beginning of flight simulation and the Link organization.
URL: http://www.link.com/history.html

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Reference Type: Magazine Article
Author: Lacagnina, Mark
Year: 2006
Title: Cross-control upset
Magazine: Aviation Safety World
Frequency: Monthly
Pages: 46-50
Date: November
Alternate Magazine: Aero Safety World
Number of Pages: 5
Keywords: upset recovery training (URT), Fairchild Metro III, New Zealand, fuel balancing
Abstract: The Metro's autopilot was engaged when the pilots induced a sideslip to balance fuel. When the autopilot reached its control limits and disengaged, the aircraft rolled and entered a spiral dive.
URL: http://www.flightsafety.org/asw/nov06/asw_nov06_p46-50.pdf
Access Date: 7/30/08

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Reference Type: Journal Article
Author: Lackner, James R.; DiZio, Paul
Year: 2005
Title: Vestibular, proprioceptive, and haptic contributions to spatial orientation
Journal: Annual Review of Psychology
Volume: 56
Pages: 115-147
Electronic Resource Number: 10.1146/annurev.psych.55.090902.142023
Number of Pages: 33
Keywords: semicircular canals, otoliths, muscle spindles, somatosensation, artificial gravity
Abstract: The control and perception of body orientation and motion are subserved by multiple sensory and motor mechanisms ranging from relatively simple, peripheral mechanisms to complex ones involving the highest levels of cognitive function and sensory-motor integration. Vestibular contributions to body orientation and to spatial localization of auditory and visual stimuli have long been recognized. These contributions are reviewed here along with new insights relating to sensory-motor calibration of the body gained from space flight, parabolic flight, and artificial gravity environments. Recently recognized contributions of proprioceptive and somatosensory signals to the appreciation of body orientation and configuration are described. New techniques for stabilizing posture by means of haptic touch and for studying and modeling postural mechanisms are reviewed. Path integration, place cells, and head

direction cells are described along with implications for using immersive virtual environments for training geographic spatial knowledge of real environments.

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Reference Type: Report
Author: Ladkin, Peter B.
Year: 2004
Title: The crash of AA587: A Guide
Institution: RVS Group, University of Bielefeld
Pages: 1-25
Date: November 18
Report Number: RVS-RR-04-03
Author's Title and Affiliation: RVS Group, University of Bielefeld
Number of Pages: 25
Keywords: American Airlines flight 587, upset recovery training (URT)
Abstract: This note considers some of the technical and sociotechnical aspects of the accident uncovered by the three-year investigation.
URL: http://www.rvs.uni-bielefeld.de/publications/Reports/CrashOfAA587.pdf
Author Address: ladkin@rvs.uni.bielefeld.de

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Reference Type: Conference Paper
Author: Lahiri, Arnab
Year: 1996
Title: Importance of spatial sound cues in simulators
Conference Name: AIAA Flight Simulation Technologies Conference
Conference Location: San Diego, CA
Publisher: American Institute of Aeronautics and Astronautics (AIAA)
Date: July 29-31
Electronic Resource Number: AIAA-1996-3551
Author's Title and Affiliation: Staff Systems Engineer, NATCO, Eagan, MN
Number of Pages: 2
Abstract: Flight simulators attempt to replicate an environment conducive to aircrew training. The designated level of the simulation is directly dependent on the resultant fidelity towards realism. This fidelity has been the key factor that has enabled progression in transfer of training both in procedures and methods. Amongst the many different cues available sound plays a very important role in a simulator training scenario. With upcoming regulations governing the fidelity of flight simulators, the status of simulated sound has been further elevated. Sufficient emphasis has, however, not been placed on the spatial aspects and effects of sound. Sound cues, especially in the cockpit, do not only alert to a single or a series of events but also attempt to provide various information regarding the source(s). Use of modern sound recording techniques can be easily utilized along with multiple sound gathering elements to obtain the kind and quality of sound data needed. These sounds can then be duplicated in a multi-channel environment for closer spatial simulation. Testing would involve the use of similar setups, though in a much simpler form which would also ensure repeatability. Simpler setups would reduce cost and time involved as well. It is necessary to justify such fidelity which would ultimately ensure not only enhanced simulation to further training requirements but reasonable methods of maintaining the integrity of the standards of the sound as well.

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Reference Type: Report
Author: Lahiri, A.
Year: 2005
Title: Significance of a qualitative handling assessment approach towards motion system requirements for flight simulators
Institution: National Simulator Program (NSP), Federal Aviation Administration (FAA)
Date: July 18
Author's Title and Affiliation: National Simulator Program, Federal Aviation Administration (FAA), Atlanta, GA
Number of Pages: 5
Abstract: Progress drives regulation and regulation drives progress. The aircraft is a classic example where one aspect is constantly trying to push the other to be a step ahead.
Notes: On 9/30/09, the website is no longer available.
URL: http://www.faa.gov/safety/programs_initiatives/aircraft_aviation/nsp/research/media/Arnab_Lahiri.rtf

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Reference Type: Journal Article
Author: Lambo, Roger
Year: 2001
Title: Panel to review relevance of flight crew licensing and training standards
Journal: ICAO Journal
Volume: 8
Author's Title and Affiliation: ICAO Secretariat
Abstract: ICAO flight crew licensing and training standards have served international aviation well in their present format for over half a century, but now need to be re-examined in light of significant changes in aircraft and training technology.

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Reference Type: Conference Proceedings
Author: Lambregts, A. A.; Nesemeier, G.; Wilborn, J. E.; Newman, R. L.
Year of Conference: 2008
Title: Airplane upsets: Old problem, new issues
Conference Name: AIAA Modeling and Simulation Technologies Conference
Conference Location: Honolulu, HI
Publisher: American Institute of Aeronautics and Astronautics (AIAA)
Date: August 18-21
Electronic Resource Number: AIAA 2008-6867
Author's Title and Affiliation: Federal Aviation Administration (FAA)
Lambregts: Chief Scientist and Technical Advisor for Control Systems, ANM-113N
Nesemeier: Senior Aerospace Engineer, Seattle Aircraft Certification Office, ANM-130S
Wilborn: Project Officer, Transport Standards Staff, ANM-113
Newman: Aerospace Engineer, Transport Standards Staff, ANM-111
Keywords: upset recovery training (URT), loss of control (LOC)
Abstract: Loss-of-control (LOC) accidents remain a major type of accidents to transport airplanes. Recent high profile accidents, such as American 587 in New York have emphasized the importance of identifying trends and developing strategies for preventing such mishaps. We reviewed fifteen years of LOC accidents to transport airplanes. We found seventy-four accidents including 3241 fatalities. Major areas of concern are 27 stall accidents, 20 accidents with ice contaminated airfoils, and eight spatial disorientation accidents. Ten accidents were exacerbated by faulty pilot recovery technique. These areas appear promising for accident prevention.
Author Address: Federal Aviation Administration, 1601 Lind Avenue South, Renton, WA, 98057

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Reference Type: Web Page
Author: Landsberg, Bruce
Year: 2001
Title: Safety pilot: Meet the PCATD
Series Editor: Landsberg, Bruce
Publisher: Aircraft Owners and Pilots Association (AOPA)
Access Year: 2006
Access Date: Sept. 6
Number of Pages: 4
URL: http://www.aopa.org/asf/asfarticles/sp9707.html#bio

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Reference Type: Electronic Article
Author: Landsberg, Bruce
Year: 2003
Title: Safety pilot: A boot in the posterior
Periodical Title: AOPA Pilot
Issue: January
Author's Title and Affiliation: Executive Director, Aircraft Owners and Pilots Association (AOPA) Air Safety Foundation
Keywords: American Airlines flight 587, upset recovery training (URT)
Abstract: (first paragraph) It's exceedingly rare to have an aircraft come apart, especially when it is flown within the design envelope. So there was great surprise and consternation when American Flight 587, an Airbus 300, shed its vertical stabilizer and rudder while flying well below maneuvering speed (VA). It would be understandable if the jet started shedding pieces at high speed after a robust control deflection, but we've all been told that if the aircraft is below VA, it will stall before bad things happen. What are the implications for pilots of light aircraft?
Access Date: October 16, 2006

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Reference Type: Journal Article
Author: Larish, John F.; Flach, John M.
Year: 1990
Title: Sources of optical information useful for perception of speed of rectilinear self-motion
Journal: Journal of Experimental Psychology
Volume: 16
Issue: 2
Pages: 295-302
Author's Title and Affiliation: University of Illinois at Urbana-Champaign
Number of Pages: 8
Keywords: optical information, rectilinear self-motion, optical edge rate, global optical flow rate
Abstract: Magnitude judgments of the speed of self-motion were examined. The principal independent variables were edge rate, global optical flow rate, and the type of texture (grid or dot). Results indicated that edge rate and global optical flow rate had additive effects on magnitude judgments, with edge rate accounting for a larger portion of the variance. Effects were independent of texture type. Secondary variables examined were viewing condition and task load. Attempts were made to control the availability of flatness cues. Evidence indicates that the effectiveness of global optical flow rate varied with the control of flatness cues. A secondary running auditory Sternberg task was used to prevent edge counting; the presence of this task did not reduce the effect of edge rate. These results replicate and extend previous work by D. H. Owen and colleagues.

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Reference Type: Workshop/Symposia
Author: Larsen, William E.
Year of Workshop: 1991
Title: Proceedings of the NASA/FAA helicopter simulator workshop
Workshop Name: NASA/FAA helicopter simulator workshop
Workshop Location: Biltmore Hotel, Santa Clara, California
Publisher: United States Department Of Commerce, National Technical Information Service
Date of Workshop: April 23-26
Author's Title and Affiliation: Federal Aviation Administration, NASA Ames Research Center, Moffett Field, CA
U.S. Department Of Commerce, National Technical Information Service, Springfield, VA 22161
Number of Pages: 192
Keywords: cockpit, simulators, helicopters, standards, training simulators, military technology, NASA programs, research and development
Abstract: A workshop was convened by the FAA and NASA for the purpose of providing a forum at which leading designers, manufacturers, and users of helicopter simulators would initiate and participate in a development process that would facilitate the formulation of qualification standards by the regulator agency. Formal papers were presented, special topics were discussed in breakout sessions, and a draft FAA advisory circular defining specifications for helicopter simulators was presented and discussed. A working group of volunteers was formed to work with the National Simulator Program Office to develop a final version of the circular. The workshop attracted 90 individuals from a constituency of simulator manufacturers, training organizations, the military, civil regulators, research scientists, and five foreign counties. A great amount of information was generated and recorded verbatim. This information is presented herein within the limits of accuracy inherent in recording, transcribing and editing spoken technical material.
Notes: Contents:
Helicopter Simulator Standards (Edward M. Boothe)
Helicopter Simulation: An Aircrew Training and Qualification Perspective (Richard A. Birnbach and Thomas M. Longridge)
Rotorcraft Master Plan (Peter V. Hwoschinksy)
Simulators for Corporate Pilot Training and Evaluation (Curt Treichel)
Training Effectiveness Assessment: Where Are We? (Greg McGowan)
Current Training: Where Are We? (Gerald Golden)
Helicopter Simulator Qualification (Brian Hampson)
Helicopter Simulation: Making It Work (Barry Payne)
Helicopter Training Simulators: Key Market Factors (John McIntosh)
Training Effectiveness Assessment: Methodological Problems and Issues (Kenneth D. Cross)
Progress Through Precedent: Going Where No Helicopter Simulator Has Gone Before (Richard J. Adams)
Transfer of Training and Simulator Qualification or Myth and Folklore in Helicopter Simulation (Jack Dohme)
Validation and Upgrading of Physically Based Mathematical Models (Ronald Du Val)
Frequency-Response Techniques for Documentation and Improvement of Rotorcraft Simulators (Mark B. Tischler)
Bandwidth and SIMDUCE as Simulator Fidelity Criteria (David Key)
Methodological Development for Evaluation of Selective-Fidelity Rotorcraft Simulation (Major William D. Lewis, D.P. Schrage, J.V.R. Prasad, and Major Daniel Wolfe)

Session Presentation Discussions:
Session A: Training: Limits, Allowances, and Future (Ronald J. Adams)
Session B: Scene Content and Simulator Training Effectiveness (Walter W. Johnson)
Session C: Low-Cost Training Alternatives: Part- and Full-Task Trainers (David A. Lombardo)
Session D: Dynamic Response and Engineering Fidelity in Simulation (Edward D. Cook)
Session E: Current Training: Where Are We? (Greg J. McGowen)
Session F: Aero Modeling (Ronald W. Du Val)
URL: http://ntrs.nasa.gov/archive/nasa/casi.ntrs.nasa.gov/19930021484_1993021484.pdf

Reference Type: Report
Author: Larsen, William E.; Randle, Robert J.; Popish, Lloyd N.
Year: 1995
Title: Vertical flight training: An overview of training and flight simulator technology with emphasis on rotary-wing requirements
Series Editor: NASA
Number of Pages: 325
Label: NASA Reference Publication 1373
DOT/FAA/CT-94/83
Keywords: vertical flight training, rotary-wing requirements, flight simulators, simulation validation, training schools, training requirements, cockpit motion, visual space perception
Notes: Contents:
Foreword - xi
Acknowledgements - xiii
Introduction - xv
1) An Overview of the Vertical Flight Industry: The Source of Training Requirements - 1
By John D. McIntosh and Lloyd N. Popish
2) Training and Training Schools: Meeting Current Requirements - 15
By Noel G. Preston
3) Training Systems Design and Development - 30
By Owen M. Lee and Carmen E. Asencio-Lee
4) Transfer of Training and Cost-Effectiveness - 61
By Daniel P. Westra and Gavan Lintern
5) The Military Quest for Flight Training Effectiveness - 87
By Jack Dohme
6) Alternative Training Systems - 131
By David A. Lombardo
7) Training Devices Manufacturing - 146
By John Carlton and Stephen Francis
8) Simulator Aero Model Implementation - 178
By Thomas S. Alderete
9) Simulation Validation in the Frequency Domain - 203
By Jeff A. Schroeder, Mark B. Tischler, Douglas C. Watson and Michele M. Eshow
10) Visual Space Perception in Flight Simulators - 256
By Robert J. Randle, Jr. and John Sinacori

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Reference Type: Report
Author: Latham, Roy
Year: 1994
Title: Achieving consistent colors and textures in visual simulation
City: Mountain View, CA
Institution: Computer Graphics Systems Development Corporation
Author's Title and Affiliation: Computer Graphics Systems Development Corporation, Mountain View, CA 94043-2330
Number of Pages: 7
Keywords: color, texture, visual simulation, color cataloging
Notes: Regarding simulators in general.

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Reference Type: Conference Paper
Author: Laughery, K. Ronald
Year: 1984
Title: Human operator modeling: A new technology for addressing human factors during design
Conference Name: IEEE 1984 National Aerospace and Electronics Conference
Conference Location: Dayton, Ohio
Date: May 21-25
Author's Title and Affiliation: Micro Analysis and Design, Boulder, CO
Number of Pages: 9
Abstract: Tools now exist which will allow human factors engineers to estimate human performance in systems early in system design. Human Factors engineers can now develop computer models and conduct experiments on human performance long before any type of prototype is available. This paper addresses four questions; 1) when should computer models of operator performance be used, 2) what are the available technologies, 3) what are some of the recent advancements in one of these technologies, and 4) what steps are involved in building a model of human operator performance in a system.

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Reference Type: Magazine Article
Author: Lavitt, Michael O.
Year: 1997
Title: Mobile Beach 1900 simulator brings training to pilots
Magazine: Aviation Week & Space Technology
Date: October 27
Number of Pages: 3
Keywords: mobile simulator, Techniflite, Skyway Airlines, Paul Ray, portable simulator

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Reference Type: Journal Article
Author: Lawther, A.; Griffin, M. J.
Year: 1988
Title: Motion sickness and motion characteristics of vessels at sea
Journal: Ergonomics
Volume: 31
Issue: 10
Pages: 1373-1394
Author's Title and Affiliation: Human Factors Research Unit, Institute of Sound and Vibration Research, University of Southampton, Southampton, S09 5NH England
Number of Pages: 22
Keywords: seasickness, motion illness, vomiting, ship motion
Abstract: Measurements of vessel motion and consequent seasickness amongst passengers have been made on six ships, two hovercraft and a hydrofoil. Data are presented for 20029 passengers surveyed on 114 voyages involving 370 hours of motion recordings. Vomiting incidence and illness rating were found to be linearly related to the root-mean-square magnitude of the vertical z-axis acceleration. Sickness increased with increasing duration of exposure and a measure of motion "dose" is examined as a convenient way of combining the variables of stimulus magnitude and duration. High frequency motion in hovercraft at about 0 multiplied by 6 Hz was found to be less provoking of sickness than similar magnitudes at lower frequencies. Motion in axes other than the vertical correlated less highly with sickness, although there was some intercorrelation between axes. The results presented enable predictions to be made of seasickness occurrence in marine vessels and other forms of transport where low frequency vertical oscillations are encountered.

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Reference Type: Journal Article
Author: Lawther, A.; Griffin, M. J.
Year: 1988
Title: A survey of the occurrence of motion sickness amongst passengers at sea
Journal: Aviation, Space, and Environmental Medicine (ASEM)
Volume: 59
Issue: 5
Pages: 399-406
Date: May
Author's Title and Affiliation: Human Factors Research Unit, Institute of Sound and Vibration Research, The University, Southampton, England
Abstract: A questionnaire survey of motion sickness occurrence on board passenger ferries has been conducted. Data were collected from 20,029 passengers on 114 voyages on 9 vessels: 6 ships, 2 hovercraft, and 1 jetfoil. Information was obtained about feelings of illness, the occurrence of vomiting, the taking of anti-seasickness tablets, the consumption of alcoholic drinks, regularity of travel by sea, age, and sex. Overall, 7% of passengers reported vomiting at some time during the journey, 21% said they felt "slightly unwell," 4% felt "quite ill," and a further 4% felt "absolutely dreadful." Both vomiting incidence and illness rating were greater in females than in males, and there was a slight decrease in sickness occurrence with increasing age. The incidence of vomiting was related to the taking of tablets and the drinking of alcohol; there were also some interaction effects with other variables. Anecdotal information from passengers is reported and consideration is given to the effects of environmental variables.

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Reference Type: Workshop/Symposia
Author: Lawver, Jim; Lee, Alfred T.
Year of Workshop: 1983
Title: Low cost training aids and devices
Workshop Name: Flight Training Technology for Regional/Commuter Airline Operation
Workshop Location: Moffett Field, CA
Publisher: National Aeronautics and Space Administration (NASA), Ames Research Center
Date of Workshop: September 28-30
Author's Title and Affiliation: Lawver: Scientific Airlines
Lee: NASA

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Reference Type: Magazine Article
Author: Learmount, David
Year: 2006
Title: Training & recruitment: Raising the bar
Magazine: Flight International
Date: November 21
Number of Pages: 3
Keywords: type rating training, recurrent training, low-cost training, ATR, flight training device (FTD), full flight trainer (FFT)
Abstract: Advanced type and recurrent training is so expensive that pilots do not get enough of it to hone all their skills. But does it have to be that way?
URL: http://www.flightglobal.com/articles/2006/11/21/210637/training-recruitment-raising-the-bar.html

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Reference Type: Magazine Article
Author: Learmount, David
Year: 2009
Title: Civil Simulators Special: Going through the motions--are motion systems for simulators on their way out?
Magazine: Flight International
Date: April 27
URL: http://www.flightglobal.com/articles/2009/04/27/325612/civil-simulators-special-going-through-the-motions-are-motion-systems-for-simulators-on-their-way-ou.html

*****

Reference Type: Workshop/Symposia
Author: Lee, Alfred T.
Year of Workshop: 1983
Title: Low-cost training technology
Workshop Name: Flight Training Technology for Regional/Commuter Airline Operation
Workshop Location: Moffett Field, CA
Publisher: National Aeronautics and Space Administration (NASA), Ames Research Center
Date of Workshop: September 28-30
Author's Title and Affiliation: NASA Ames Research Center, Moffett Field, CA 94035
Abstract: (from first page) You're going to hear a great deal in this workshop about technology and air crew training. I'd like to use this opportunity to point out some important differences between training technology on the one hand and the technology of flight simulation on the other. I will also describe two relatively inexpensive training systems in order to demonstrate how low-cost technology when properly applied can meet training needs. Finally, I would like to discuss the potential impact of new cockpit technology on training and, I think, some innovative approaches that are being tried to solve these problems.

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Reference Type: Conference Paper
Author: Lee, Alfred T.
Year: 2003
Title: Air traffic control simulation and aircrew training
Conference Name: Simulation of the Environment Conference
Conference Location: London, UK
Publisher: Royal Aeronautical Society (RAeS)
Date: 2003
Number of Pages: 14
Abstract: Air Traffic Control (ATC) communication is essential for safe and efficient flight operations. Simulation of these communications during line-oriented training and evaluation would be a logical requirement for all types of flight simulator training. However, a high degree of fidelity is currently not possible for simulators despite the substantial investment in flight simulation technology development which, in every other aspect of flight operations, currently provides significant operational realism. This lack of realistic ATC communications simulation fidelity in airline training simulators may affect crew performance and an instructor's ability to evaluate that performance. In any case, the utility of line-oriented simulations as valid crew assessment tools may be compromised. An assessment of the impact of variations in ATC fidelity on aircrew training and evaluation is needed in order to identify the potential benefits, if any, that may arise from improvements in existing communications simulation technologies. Toward this end, a field study was conducted to evaluate the effects of variations in ATC communications simulation fidelity on crew and instructor/evaluator behavior in Line-Oriented Flight Training (LOFT) at a major airline training organization. Results of the study indicate that variations in ATC fidelity do affect crew communications behavior. When a high level of ATC fidelity is present, a level comparable to that of line operations, management of communications both within and outside the cockpit is affected significantly. While there was no evidence that crews commit more communications procedural errors

with high fidelity ATC simulations, the presence of high fidelity frequency chatter regularly produced call sign confusion errors. Crew and instructor comments reiterated the importance of high fidelity ATC communications simulation in LOFT environments. Implications of the findings for the role of ATC fidelity in line-oriented training are discussed.

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Reference Type: Book
Author: Lee, Alfred T.
Year: 2005
Title: Flight simulation: Virtual environments in aviation
City: Burlington, VT
Publisher: Ashgate
Number of Pages: 137
Author's Title and Affiliation: Beta Research, Inc. Los Gatos, USA

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Reference Type: Conference Paper
Author: Lee, Alfred T.; Bussolari, Steven R.
Year: 1986
Title: Flight simulator requirements for airline transport training: An evaluation of motion system design alternatives
Conference Name: IEE Second International Conference on Simulators
Conference Location: University of Warwick, United Kingdom

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Reference Type: Journal Article
Author: Lee, Alfred T.; Bussolari, Steven R.
Year: 1989
Title: Flight simulator platform motion and air transport pilot training
Journal: Aviation Space and Environmental Medicine
Volume: 60
Issue: 2
Pages: 136-140
Date: February 1
Author's Title and Affiliation: Lee: M.A., Ph.D., NASA Ames Research Center
Bussolari: M.S., Ph.D., Massachusetts Institute of Technology
Number of Pages: 5
Keywords: (jbc) keywords-flight simulator, platform motion, air transport pilot, training
Abstract: The influence of flight simulator platform motion on pilot training and performance was examined in two studies utilizing a B-727-200 aircraft simulator. The simulator, located at Ames Research Center, is certified by the FAA for upgrade and transition training in air carrier operations. Subjective ratings and objective performance of experienced B-727 pilots did not reveal any reliable effects of wide variations in platform motion design. Motion platform variations did affect the control behavior of pilots with no prior heavy aircraft flying experience. The effect was limited, however, to pitch attitude control inputs during the early phase of landing training. Implications for the definition of platform motion requirements in air transport training are discussed.

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Reference Type: Workshop/Symposia
Author: Lee, Alfred T.; Lauber, John K.
Year of Workshop: 1983
Title: Regional airline association/NASA workshop proceedings
Workshop Name: Flight Training Technology for Regional/Commuter Airline Operation
Workshop Location: Moffett Field, CA
Publisher: National Aeronautics and Space Administration (NASA), Ames Research Center
Date of Workshop: September 28-30
Number of Pages: 263

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Reference Type: Report
Author: Lee, W-S.; Kim, J-H.; Cho, J-H.
Year: 1997
Title: Development of a driving simulator
Institution: Society of Automotive Engineers (SAE)
Author's Title and Affiliation: Department of Automotive Engineering, Kookmin University, 861-1 Chungnung-dong, Sungbuk-gu, Seoul, 136-702, Korea
Number of Pages: 6
Keywords: driving simulator, real-time vehicle simulation, visual/audio system, motion system, control force loading system, system integration
Abstract: Driving simulators are used effectively for vehicle system development, human factor study, and other purposes by enabling to reproduce actual driving conditions in a safe and tightly controlled environment. This paper describes a driving simulator developed for design and evaluation of full-scale driving simulators and for driver-vehicle interaction study. The simulator consists of a real-time vehicle simulation system, a visual and audio system, a motion system, a control force loading system, and an experiment console. The real-time vehicle simulation system supervises overall operation of the simulator and also simulates dynamic motion of realistic vehicle models in real-time. The economical visual system generates high fidelity driving scenes that are displayed on a screen by a projector. The motion system generates realistic motion cue using a six degree-of-freedom Stewart platform driven hydraulically. The control force loading system acts as an interface between a driver and the simulator. The experiment console monitors the status of the simulator in operation and also collects and manages experimental data.

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Reference Type: Magazine Article
Author: Lehman, Chris
Year: 2006
Title: Flying down to Orlando
Magazine: 9th annual World Aviation Training Conference (WATS)
8th Regional Aviation Training Conference and Tradeshow (RATS)
Date: 2006
Number of Pages: 3
Abstract: The 9th annual World Aviation Training Conference (WATS), and 8th annual Regional Airline Training Conference and Tradeshow (RATS) landed in Orlando, Florida April 4-6. Editor in Chief Chris Lehman was Conference Chair and files this report.

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Reference Type: Journal Article
Author: Lehman, Chris
Year: 2007
Title: A clean sheet from CAE
Journal: The Journal for Civil Aviation Training (CAT)
Issue: 3

Pages: 32
Number of Pages: 1
Abstract: CAE recently celebrated its 60th anniversary with a party and technology display at its head office in Montreal. CAT editor in cheif Chris Lehman caught up with Marc Parent, CAE Group president, Simulation Products and Military Training & Services.

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Reference Type: Journal Article
Author: Lehman, Chris
Year: 2007
Title: Growing while green
Journal: The Journal for Civil Aviation Training (CAT)
Issue: 4
Pages: 6-10
ISSN: 0960-9024
Number of Pages: 5
Abstract: While the airline industry appears to be the latest target of the environmental lobby, expansion continues unabated with the training and simulation sector offering up unprecedented growth, technological advancement and regulatory evolution. Personnel supply and demand issues are becoming acute, while the training industry itself continues its commercial consolidation. Editor in Chief Chris Lehman looks at a few of the major developments of the past year.

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Reference Type: Conference Paper
Author: Leibowitz, H. W.
Year: 1986
Title: Recent advances in our understanding of peripheral vision and some implications
Conference Name: Human Factors Society 30th Annual Meeting
Author's Title and Affiliation: Pennsylvania State university, University Park, PA
Number of Pages: 3
Abstract: The characteristics of peripheral vision and its relation to object recognition and spatial orientation functions are reviewed in the light of recent developments. Implications of these findings and their relevance to some selected human engineering problems are discussed.

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Reference Type: Journal Article
Author: Lekhel, Hamid; Popov, Konstantin; Anastasopoulos, Dimitri; Bronstein, Adolfo; Bhatia, Kailash; Marsden, C. David; Gresty, Michael
Year: 1997
Title: Postural response to vibration of neck muscles in patients with idiopathic torticollis
Journal: Brain: A Journal of Neurology
Volume: 120
Issue: 4
Pages: 583-591
ISSN: 0006-8950 (Print)
1460-2156 (Electronic)
Electronic Resource Number: 10.1093/brain/120.4.583
Number of Pages: 9
Keywords: postural responses to vibration of neck muscles & vestibular dysfunction, patients with idiopathic spasmodic torticollis vs bilateral labyrinthine defective
Abstract: Vibration of the dorsal muscles of the neck, simulating lengthening, in standing man causes a visible forwards tilt of the body shown on posturography as a tonic sagittal sway deviation. According to the theory that posture is organized with respect to a 'body schema' this deviation is a result of an interpretation of the concurrent neck afferent and vestibular signals. Considering the hypothesis that neck afferent signals may be misinterpreted in patients with spasmodic torticollis (ST) causing abnormal

postural responses, we recorded body sway induced by unilateral dorsal neck muscle vibration in 22 idiopathic ST patients (19 treated with botulinum toxin) during upright stance with eyes closed. Comparison groups were 19 normal subjects and 11 patients with bilateral loss of vestibular function (labyrinthine defective, LD) in whom neck afference should be intact. Both treated and untreated ST and LD patients had absent or diminished sway deviations. When sway deviation did occur, it was sagitally oriented as with normal subjects and unrelated to ST head turns. In most ST and LD patients, neck vibration induced neck extension, an effect which is observed in normal subjects only if the torso is retrained. The results suggest that neck proprioceptive input retains local postural functions in ST, however, it is relatively ignored in the context of the whole body postural control and spatial orientation. The mild disorders of vestibular function reported in torticollis patients may be due to an inability to calibrate vestibular signals by reference to corroborative signals from neck proprioception.

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Reference Type: Government Document
Author: Leland, R.; Rogers, R.; Boquet, A.; Glaser, S.
Year: 2009
Title: An experiment to evaluate transfer of upset-recovery training
Department: DOT
Pages: 18
Report Number: DOT/FAA/AM-09/17
Keywords: airplane upset recovery training, upset recovery, flight simulation, training transfer, centrifuge based flight simulator, microsoft flight simulator
Abstract: Air transport training programs provide simulator-based upset-recovery instruction for company pilots. However, no prior research demonstrates that such training transfers to an airplane in flight. We report on an
FAA-funded research experiment to evaluate upset-recovery training transfer. Two groups of participants were given simulator-based training in upset-recovery, one in a high-end centrifuge-based device, the other using
Microsoft Flight Simulator running on desktop computers. A third control group received no upset-recovery training at all. All three groups were then subjected to serious in-flight upsets in an aerobatic airplane. Pilots from both trained groups significantly outperformed control group pilots in upset-recovery maneuvering. However, performance differences between pilots from the two trained groups were less distinct. Moreover, pilot
performance in both trained groups fell well short of the performance exhibited by pilots experienced in all attitude flight. Although we conducted flight testing in a general aviation airplane, our research has important
implications for heavy aircraft upset-recovery trainers.

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Reference Type: Newspaper Article
Reporter: Levin, Alan
Year: 2010
Title: NTSB: Pilots need air-hazard skills
Newspaper: USA Today
Frequency: Daily
Issue Date: 3/9/2010
URL: http://www.usatoday.com/travel/flights/2010-03-08-flight-simulator-accidents-pilot-training_N.htm

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Reference Type: Newspaper Article
Reporter: Levin, Alan
Year: 2010
Title: Simulator training flaws tied to airline crashes
Newspaper: USA Today
Frequency: Daily
Issue Date: 08/31/2010
URL: http://travel.usatoday.com/flights/2010-08-31-1Acockpits31_ST_N.htm

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Reference Type: Journal Article
Author: Levison, William; Baron, Sheldon; Kleinman, David
Year: 1969
Title: A model for human controller remnant
Journal: IEEE Transactions on Man-Machine Systems
Volume: MMS-10
Issue: 4
Pages: 101-108
Date: December
Author's Title and Affiliation: IEEE Members
Number of Pages: 8
Abstract: A model for human controller remnant is postulated in which remnant is considered to arise from an equivalent observation noise vector whose components are linearly independent white noise processes. Extensive analysis of data obtained from simple manual control systems verifies that this model structure holds over a wide range of input amplitudes and bandwidths, vehicle dynamics, and display locations. When the display is viewed foveally, the component noise processes are proportional to the variances of the displayed quantities. This constant of proportionality is independent of input parameters and of vehicle dynamics.

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Reference Type: Report
Author: Levison, William H.
Year: 1981
Title: Effects of whole-body motion simulation on flight skill development
City: Washington, DC
Institution: Bolling Air Force Base, Air Force Office of Scientific Research
Date: October
Type: Final Report
Report Number: AFOSR-TR-82-006
Author's Title and Affiliation: Bolt Beranek and Newman Inc., 10 Moulton Street, Cambridge, MA 02238
Keywords: human operator technology, human operator modeling, learning, optimal control model, parameter identification, motion cueing
Abstract: Progress was made toward the development of models for piloting skill acquisition. The following tasks were accomplished: (1) design of an experiment to study visual and motion cue integration in a multi-axis control task; (2) enhancement of the optimal control pilot model; (3) further development of a scheme for automatic identification and significance testing of "pilot-rated" model parameters; (4) analysis of control strategy development; (5) study of the relationship between task structure and pilot response limitations; (6) test of a multiplicative motor noise model; and (7) a brief literature search on adaptive control and identification algorithms for potential application to models for control-strategy development.

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Reference Type: Report
Author: Levison, William H.; Junker, Andrew M.
Year: 1977
Title: A model for the pilot's use of motion cues in roll-axis tracking tasks
City: Wright-Patterson Air Force Base, OH
Institution: Aerospace Medical Research Laboratory, Aerospace Medical Division, Air Force Systems Command
Date: June
Type: Interim Scientific Report
Report Number: AMRL-TR-77-40
Author's Title and Affiliation: Bolt Beranek and Newman Inc., Cambridge, MA 02138
Number of Pages: 76
Keywords: human operator technology, human operator modeling, motion, optimal control model
Abstract: An experimental and analytical study was undertaken jointly by the Aerospace Medical Research Laboratory and Bolt Beranek and Newman Inc. to test a model for the pilot's use of motion cues in roll-axis tracking tasks. Simulated target-following and disturbance-regulation tasks were explored with subjects using visual-only and combined visual and motion cues. The effects of motion cues on task performance and pilot response behavior were appreciably different for the two task configurations and were consistent with data reported in earlier studies for similar task configurations.
The "optimal-control" model for pilot/vehicle systems provided a task-independent framework for accounting for the pilot's use of motion cues. Specifically, the availability of motion cues was modeled by augmenting the set of perceptual variables to include position, rate, acceleration, and acceleration-rate of the motion simulator; and results were consistent with the hypothesis of attention-sharing between visual and motion variables. This straightforward informational model allowed accurate model predictions of the effects of motion cues on a variety of response measures for both the target-following and disturbance-regulation tasks.

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Reference Type: Journal Article
Author: Li, Wen-Chin; Harris, Don
Year: 2006
Title: The evaluation of the decision making processes employed by cadet pilots following a short aeronautical decision-making training program
Journal: International Journal of Applied Aviation Studies
Volume: 6
Issue: 2
Pages: 315-334
Number of Pages: 20
Abstract: Many aeronautical decision-making (ADM) mnemonic-based methods exist. However, there is no empirical research that suggests that they are actually effective in improving decision-making. Klein (1993), in his study of naturalistic decision making, suggested that the decision-making process centers around two processes: situation assessment to generate a plausible course of action and mental simulation to evaluate that course of action for risk management. In this study a short, ADM training course was constructed around two mnemonic methods, SHOR (Stimuli, Hypotheses, Options, and Response) and DESIDE (Detect, Estimate, Set safety objectives, Identify, Do, Evaluate). Forty-one pilots from the Republic of China Tactical Training Wing participated: half received a short ADM training course and half did not. After training, the procedural knowledge underpinning their Situation Assessment and Risk Management ability, two skills essential for successful decision-making, were evaluated using pencil and paper-based knowledge tests based upon several demanding tactical flight situations. These scenarios were designed to encompass the six basic types of decision making described by Orasanu (1993); go/no go decisions; recognition-primed decisions; response selection decisions; resource management decisions; non-diagnostic procedural decisions, and decisions requiring creative problem-solving. The results show gains attributable to the decision making training course in both situation assessment and risk management skills. The results strongly suggest that ADM is trainable and such a training course is effective in improving the bases of in-flight decision-making.

Reference Type: Conference Paper
Author: Liao, J.; Milgram, P.
Year: 1991
Title: On validating human performance simulation models
Conference Name: Human Factors Society 35th Annual Meeting
Author's Title and Affiliation: Department of Industrial Engineering, University of Toronto
Number of Pages: 5
Abstract: This paper addresses some of the difficult and elusive problems associated with validating human performance simulation models. Simulation validity can be subclassified into input and validity, structure validity and output validity. Of these, output validity is the most objective and also the most important, because it determines whether or not the purpose of the modeling effort can be met. In testing for output validity analysis of variance alone is not sufficient for validating human performance simulation models, as is often taken for granted by many researchers. A more systematic approach is proposed and its implications discussed. The approach is based on considering analysis of variance in terms of the power of the test and a predetermined level of acceptable differences between model and reality.

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Reference Type: Conference Proceedings
Author: Lichter, Matthew D.; Bateman, Alec J.; Balas, Gary J.
Year of Conference: 2009
Title: Flight test evaluation of a run-time stability margin estimation tool
Conference Name: AIAA Guidance, Navigation, and Control Conference
Conference Location: Chicago, IL
Publisher: American Institute of Aeronautics and Astronautics (AIAA)
Pages: 1-21
Date: Aug. 10-13
Electronic Resource Number: AIAA-2009-6257
Author's Title and Affiliation: Lichter: Research Scientist, Barron Associates, Inc., Charlottesville, VA
Bateman: Principal Research Scientist, Barron Associates, Inc., Charlottesville, VA
Balas: MUSYN, Inc., Minneapolis, MN
Number of Pages: 21
Keywords: Run-time Observation-based Margin Estimation (ROME), upset recovery training (URT)
Abstract: This paper describes a flight test evaluation of the Run-time Observation-based Margin Estimation (ROME) software tool for monitoring control law stability margins on-line in quasi-real-time. ROME uses frequency-domain, nonparametric system identification to identify eroding margins so that corrective action can be taken in a timely manner. ROME can be used in operational settings to identify adverse conditions such as vehicle icing, damage, and failures, and in flight test settings to minimize risk and expedite verification and validation. It uses a general approach that can be applied both to next-generation vehicles with advanced control systems, and as a retrofit to the existing operational fleet. A baseline version of the ROME tool was demonstrated in a flight test environment during a recent deployment of NASA Langley's AirSTAR Testbed. The initial testing evaluated the near real-time system identification and stability margin estimation capabilities of ROME. The flight tests also afforded an opportunity to evaluate several key aspects of the software implementation including the interface to the real-time data stream from the AirSTAR Mobile Operation Station. The flight testing validated the baseline capabilities of the ROME tool, including near real-time system and margin identification.

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Reference Type: Journal Article
Author: Lind, Rick; Brenner, Marty
Year: 1998
Title: Incorporating flight data into a robust aeroelastic model
Journal: Journal of Aircraft
Volume: 35
Issue: 3

Pages: 470-477
Number of Pages: 8
Keywords: Aeroelastic Model
Abstract: Stability analysis and control synthesis for high-performance aircraft must account for errors in the aircraft model. This paper introduces a method to update a theoretical model using measured flight data. Variations between the flight data and model are represented as uncertainty operators in a robust stability framework. The structured singular value can directly account for these uncertainty operators to compute stability margins robust to the associated dynamical variations. This procedure is used to formulate an uncertain model of an F/A-18 fighter aircraft and compute stability margins that indicated the worst-case flutter conditions.

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Reference Type: Conference Proceedings
Author: Linklater, Amy; Slutz, Jeff
Year of Conference: 2007
Title: Exploring the Larger Amplitude Multi-mode Aerospace Research Simulator's motion drive algorithms
Conference Name: AIAA Modeling and Simulation Technologies Conference and Exhibit
Conference Location: Hilton Head, SC
Publisher: American Institute of Aeronautics and Astronautics (AIAA)
Date: August 20-23
Electronic Resource Number: AIAA 2007-6470
Author's Title and Affiliation: Linklater: Associate Aerospace Engineer, Air Vehicles Technology and Assessment Branch, Air Force Research Laboratory, 2180 8th St. Building 145 Wright-Patterson, OH, 45433
Slutz: Senior Simulation Engineer, Protobox, Air Force Research Laboratory, 2180 8th St. Building 145 Wright-Patterson, OH, 45433
Abstract: Over the past few years there has been continued interest in using motion-based simulation to evaluate the flying and handling qualities of future aircraft concepts. The Large Amplitude Multi-mode Aerospace Research Simulator (LAMARS) has been utilized to reduce risk for flight tests and test the constraints on new aircraft designs. The LAMARS is a one of a kind, five-degree-of-freedom motion simulator located in the Aerospace Vehicles Technology Assessment and Simulation Laboratory at Wright-Patterson Air Force Base. The simulator is driven by software that was developed in 1974 when the system was originally delivered to the Air Force Research Laboratory. This drive software is composed of various combinations of linear filters designed to provide onset cueing. One of the constraints on this motion drive algorithm was the computer processing power available in the 1970s. With today's processing powers the possibility to add "intelligence" to the drive algorithms could further improve the onset cueing. Advances in control theory may allow changes to the motion drive algorithm to be made which could provide more realistic motion cueing. Several new options for the motion drive algorithms are currently being researched. Nonlinear and linear optimal control techniques are being investigated to see if cost functions based on maximizing the true cues while minimizing the false cues could be applied to motion cueing. Adaptive control algorithms capable of dynamically adjusting filter parameters based on current accelerations, velocities and positions to avoid hitting system limits are being explored. Closed-loop algorithms utilizing feedback from a calibrated pilot instrumentation package are being researched. Algorithms based on "smart washouts" along with human perception effects are also being considered. These new techniques will eventually be compared to the current motion algorithm in a simulation study to try and improve the motion cueing of LAMARS. This paper will discuss the current motion drive algorithm in some detail and some of the newer techniques being considered.

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Reference Type: Journal Article
Author: Lintern, Gavan
Year: 1991
Title: An informational perspective on skill transfer in human-machine systems
Journal: Human Factors
Volume: 33
Issue: 3
Pages: 251-266
Author's Title and Affiliation: University of Illinois, Savoy, IL
Number of Pages: 16
Abstract: Differentiation of perceptual invariants is proposed as a theoretical approach to explain skill transfer for control at the human-machine interface. I propose that sensitivity to perceptual invariants is enhanced during learning and that this sensitivity forms the basis for transfer of skill from one task to another. The hypothesis implies that detection and discrimination of critical features, patterns, and dimensions of difference are important for learning and for transfer. This account goes beyond other similarity conceptions of transfer. To the extent that those conceptions are specific, they cannot account for effects in which performance is better following training on tasks that are less rather than more similar to the criterion task. In essence, this is a theory about the central role of low-dimensional informational patterns for control of behavior within a high-dimensional environment, and about the adjustment of an actor's sensitivity to changes in those low-dimensional patterns.

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Reference Type: Journal Article
Author: Lintern, Gavan; Garrison, William
Year: 1992
Title: Transfer effects of scene content and crosswind in landing instruction
Journal: International Journal of Aviation Psychology (IJAP)
Volume: 2
Issue: 3
Pages: 225-244
Author's Title and Affiliation: University of Illinois at Urbana-Champaign, Aviation Research Laboratory, Institute of Aviation
Number of Pages: 20
Abstract: Transfer of landing skills was tested from a high-detail pictorial, low-detail pictorial, or symbolic scene and from a zero, moderate, or high level of crosswind to a high-detail pictorial scene and a moderate level of crosswind. There were significant differential transfer effects as assessed by measures of accuracy and stability in lateral control. Training with pictorial scenes (whether of high or low detail) was superior to training with a symbolic scene, but there was no general transfer advantage from training with high versus low scene detail. Nor was there any general advantage of training with the transfer level of crosswind. In contrast to the prediction of a high-fidelity theory of transfer, the data show that values of crosswind higher or lower than the transfer value can be advantageous in certain circumstances.

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Reference Type: Conference Paper
Author: Lintern, Gavan; Garrison, William
Year: 1996
Title: Simulation for flight training
Conference Name: Flight and Ground Vehicle Simulation Update
Conference Location: State University of New York at Binghamton
Date: January 22-26
Author's Title and Affiliation: University of Illinois at Urbana-Champaign, Aviation Research Laboratory
Number of Pages: 28
Abstract: The modern flight-training simulator is intended to provide safe, economical and efficient instruction of flight control skills. At issue is how a flight simulator can be designed to ensure the

satisfaction of those goals. One approach is to seek high fidelity; that is to design and tune the simulator so the it mimics to the closest possible extent the perceptual sensations of real flight. The pursuit of high-fidelity can, however be a costly exercise. A more rational design approach would be to ascertain what dimensions of a simulation impact training effectiveness. Such an approach might result in the design of systems that are less costly but equally effective. Cost effectiveness of simulators may be improved by eliminating simulator features that do not contribute to training effectiveness and by implementing special instructional strategies that speed learning. The evidence in support of both approaches is reviewed in these notes.

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Reference Type: Book Section
Author: Lintern, G.; McMillan, G.
Year: 1990
Title: Transfer for flight simulation
Book Title: Aviation Instruction and Training
Pages: 130-162
Author's Title and Affiliation: Charles River Analytics
Number of Pages: 33
Keywords: transfer, transfer experiment, visual displays, proprioceptive motion cueing, system dynamics, skill transfer
Abstract: The modern flight-training simulator is intended to provide a vehicle for safe, economical and efficient instruction of flight control skills. At issue is how a flight simulator can be designed to ensure the satisfaction of those goals. The normal design approach is to seek high fidelity; that is to design and tune the simulator so that it mimics to the closest possible extent the perceptual sensations of real flight. The pursuit of high-fidelity can, however, be a costly exercise. A more rational design approach would be to evaluate what dimensions of these components impact training effectiveness. Such an approach should result in the design of systems that are less costly but equally effective.

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Reference Type: Journal Article
Author: Lintern, Gavan; Roscoe, Stanley N.; Koonce, Jefferson M.; Segal, Leon D.
Year: 1990
Title: Transfer of landing skills in beginning flight training
Journal: Human Factors
Volume: 32
Issue: 3
Pages: 319-327
Author's Title and Affiliation: Lintern, Koonce and Segal: University of Illinois at Urbana-Champaign, Savoy, IL
Roscoe: Aviation Sciences, Las Cruces, NM
Number of Pages: 9
Abstract: Beginning flight students from the University of Illinois flight training program were given two sessions of landing practice in a simulator with a computer-animated contact landing display before they commenced intensive landing practice in the aircraft. For each experimental student there was a control student, paired with the same instructor, who received no landing practice in the simulator. Experimental students required significantly fewer presolo landings in the airplane than did the paired controls, representing a potential savings of about 1.5 presolo flight hours per student. These data show that pretraining with a moderately detailed, yet relatively inexpensive, computer-animated landing display can offer worthwhile savings in flight time. Some students were provided adaptive visual augmentation during their simulator training, and there was evidence of incremental transfer attributable to this instructional feature.

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Reference Type: Journal Article
Author: Lintern, Gavan; Roscoe, Stanley N.; Sivier, Jonathan E.
Year: 1990
Title: Display principles, control dynamics, and environmental factors in pilot training and transfer
Journal: Human Factors
Volume: 32
Issue: 3
Pages: 299-317
Author's Title and Affiliation: Lintern, Sivier: University of Illinois at Urbana-Champaign, Savoy, IL
Roscoe: Aviation Sciences, Las Cruces, NM
Number of Pages: 19
Abstract: Sixty-four flight-naive men were tested in a fractional factorial, quasi-transfer experiment to examine the effects of four display factors, one control response factor, and one environmental factor on acquisition and transfer of aircraft landing skills. An additional 12 trainees served as experimental controls. Transfer was measured from each of 64 experimental training conditions to a criterion condition with a conventional inside-out pictorial contact display, normal simulator control dynamics, and a 5-knot crosswind. Transfer was better following training with pictorial displays than with symbolic displays, and with normal rather than reduced bank control order. Interactions of crosswind with predictive augmentation and with bank control order showed that for some conditions, transfer benefited from training with predictive augmentation and from training without crosswind.

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Reference Type: Journal Article
Author: Lintern, Gavan; Taylor, Henry L.; Koonce, Jefferson M.; Kaiser, Robert H.; Morrison, Gregory A.
Year: 1997
Title: Transfer and quasi-transfer effects of scene detail and visual augmentation in landing training
Journal: International Journal of Aviation Psychology (IJAP)
Volume: 7
Issue: 2
Pages: 149-169
Author's Title and Affiliation: Lintern, Taylor, Kaiser, and Morrison: University of Illinois, Institute of Aviation, Savoy, IL
Koonce: University of Central Florida, Orlando, Center for Applied Human Factors in Aviation, FL
Number of Pages: 21
Keywords: transfer, quasi-transfer, scene detail, visual augmentation, landing training
Abstract: Beginning flight students were taught landings in a flight simulator with a visual landing display to examine the effects of scene detail, visual augmented guidance, and number of landing training trials. Some students were trained in a control condition with no visual display. Transfer was assessed in the airplane in relation to the amount of landing training required prior to release for solo. Training with a low-detail scene was better for transfer than was training with a moderate-detail scene. An interaction between scene detail and augmented guidance showed that augmented guidance enhanced transfer when used in training with a low-detail scene but degraded transfer when used in training with a moderate-detail scene. The data also show that both visual and nonvisual training in the simulator build skills that enhance transfer.

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Reference Type: Conference Proceedings
Author: Liu, Fangfei; Grant, Peter R.
Year of Conference: 2009
Title: Ground-based simulation of airplane upset recovery
Conference Name: AIAA Modeling and Simulation Technologies Conference
Conference Location: Chicago, IL
Publisher: American Institute of Aeronautics and Astronautics (AIAA)
Pages: 1-13

Date: August 10
Electronic Resource Number: AIAA-2009-5828
Author's Title and Affiliation: Liu: MASc Candidate, Institute for Aerospace Studies, University of Toronto, Toronto, Ontario, Canada
Grant: Associate Professor, Institute for Aerospace Studies, University of Toronto, Toronto, Ontario, Canada
Number of Pages: 13
Keywords: upset recovery training (URT)
Abstract: Loss-of-control has become a major cause of worldwide commercial airplane accidents in recent years. The focus of this paper is on one type of loss-of-control condition; airplane upset. Concerns over the increasing number of loss-of-control and upset accidents have led to the development of various preventative strategies. One of the strategies proposed for upset prevention is the use of ground-based flight simulators for upset recovery training. Pilot training using ground-based flight simulators has great advantage over training using real aircraft in terms of safety, cost, and time-investment. However, two critical short-comings exist. One of them is that the simulation aerodynamic database is not typically valid beyond the aircraft's normal flight envelope. Another shortcoming is that the motion cues provided by the conventional hexapod motion system and associated motion drive software used in typical ground-based flight simulators may not be sufficient to achieve positive transfer of training. The on-going research from the Flight Simulation Research Group at University of Toronto intends to look at both of these shortcomings. The ultimate goal is to have an understanding of the simulator requirements for upset recovery training and develop simulator tools to support such training. This paper describes the approach taken to address the two shortcomings and shows the preliminary work on constructing an enhanced aerodynamic database.

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Reference Type: Conference Proceedings
Author: Loftus, J.; Grant, P.R.
Year of Conference: 2007
Title: Motion simulation of flexible aircraft
Conference Name: AIAA Modeling and Simulation Technologies Conference and Exhibit
Conference Location: Hilton Head, SC
Publisher: American Institute of Aeronautics and Astronautics (AIAA)
Date: August 20-23
Electronic Resource Number: AIAA 2007-6475
Author's Title and Affiliation: Loftus: MASc student,
Grant: Professor
Vehicle Dynamics and Simulation Division, University of Toronto Institute for Aerospace Studies, Toronto, Ontario, M5T 2B6, Canada
Abstract: This study investigates new methods for improving motion simulation of flexible aircraft. In particular, the work concentrates on improving the accuracy of flexible aircraft motion simulation by splitting motion signals into their oscillating and non-oscillating components. The non-oscillating component of the motion signals is processed through the conventional motion drive algorithm (MDA), while the oscillating component of the motion signals bypass the MDA and the distortions it causes. Five different methods for separating the motion signals are investigated. Each method is implemented for a Rockwell B1 Bomber flexible aircraft model, and the UTIAS Classical Motion Drive Algorithm utilizing the CW2 coefficients. The fuselage-flexing separation method is recommended for aircraft of relatively high natural structural frequencies, and the force contribution separation method is recommended for aircraft with low natural structural frequencies.

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Reference Type: Magazine Article
Author: Lombardo, David A.
Year: 2001
Title: Special report: Flight crew training
Magazine: Aviation International News
Date: August 2001
Number of Pages: 9

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Reference Type: Magazine Article
Author: Long, Chris
Year: 2006
Title: New training philosophy at Airbus
Magazine: Journal for Civil Aviation Training (CAT)
Issue Number: 1
Pages: 21-22
Number of Pages: 2
Keywords: Airbus, maintenance training, learning theory
Abstract: The advent of the Airbus A380 has spurred development in a whole range of disciplines, not least in maintenance training methodologies.
URL: http://cat.texterity.com/cat/2006-1/

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Reference Type: Journal Article
Author: Long, Chris
Year: 2009
Title: The challenge of simulating ATC- RAeS flight crew training conference
Journal: Civil Aviation Training Magazine
Pages: 34-35
Date: June 2009
Number of Pages: 2

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Reference Type: Conference Paper
Author: Longridge, Thomas; Bürki-Cohen, Judith; Go, Tiauw H.; Kendra, Andrew J
Year: 2001
Title: Simulator fidelity considerations for training and evaluation of today's airline pilots
Conference Name: The 11th International Symposium on Aviation Psychology
Conference Location: Columbus, OH
Date: March 5-8
Number of Pages: 8
Abstract: Regulatory changes in response to today's airline pilot training and evaluation needs push the twin issues of effectiveness and affordability of flight simulators for use by U.S. airlines to the forefront. The Federal Aviation Administration (FAA) is sponsoring two research programs with high pay-off potential in this area, namely, platform motion and realistic radio communications. This paper describes the rationale and the initial results of this work.
URL: http://www.volpe.dot.gov/hf/docs/isap-2001.doc

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Reference Type: Conference Paper
Author: Longridge, Thomas; Ray, Paul; Boothe, Edward; Bürki-Cohen, Judith
Year: 1996
Title: Initiative towards more affordable flight simulators for U.S. commuter airline training
Conference Name: Training: Lowering the Cost, Maintaining the Fidelity
Conference Location: London
Publisher: Royal Aeronautical Society (RAeS)
Date: May 15-16
Author's Title and Affiliation: Longridge: Manager, Advanced Qualification Program, Federal Aviation Administration (FAA), Washington, DC
Ray: Manager, National Simulator Program, Federal Aviation Administration (FAA), Washington, DC
Boothe: Consultant, Flight Simulation and Training, Atlanta, GA
Bürki-Cohen: Engineering Psychologist, Volpe National Transportation Systems Center, Department of Transportation, Cambridge, MA
Number of Pages: 17
Abstract: Recent regulatory action, coupled to a policy of encouraging commuter airlines to conduct all pilot training and checking activities in ground based equipment, has created an impetus to consider how best to ameliorate the conditions which have discouraged the use of such equipment for pilot recurrent training by commuter airlines in the United States. This paper compares the relative merits of permitting additional recurrent training credit for enhanced flight training devices versus revising the qualification standards for Level B full flight simulators to achieve enhanced affordability. The current status of an ongoing Level B flight simulator qualification standards review, results to date, and future plans, including plans for the development of a comprehensive applied research program, are discussed.

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Reference Type: Conference Paper
Author: Longridge, Thomas; Thomas, Mel; Fernie, Andrew ; Williams, Terry; Wetzel, Paul
Year: 1989
Title: Design of an eye slaved area of interest system for the simulator complexity testbed
Conference Name: Interservice/Industry Training, Simulation & Education (I/ITSEC) Conference
Author's Title and Affiliation: Longridge: U.S. Army Research Institute, Aviation R&D Activity, Fort Rucker, AL
Thomas: U.S. Air Force Human Resources Lab, Operations Division, Williams AFB, AZ
Fernie, Williams: CAE Electronics, Ltd, Montreal, Canada
Wetzel: University of Dayton Research Institute, Higley, AZ
Number of Pages: 9
Abstract: The Simulator Complexity Testbed (SCTB) is a highly modular flight simulator for experimental research focused on US Army Aviation advanced rotary wing combat. A major component in the development of the helmet mounted fiber optic display media for this device is an eye slaved area-of-interest (AOI). In order to provide for an accurate, reliable, and robust helmet mounted eye tracker to support proper system operation, the engineering development of competing eye tracking designs was initiated under a cooperative US Army/US Air Force/Canadian cost shared development program. This paper describes the overall design of the SCTB eye slaved, servo driven optical system and discusses the issues involved in its development.

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Reference Type: Conference Paper
Author: Longridge, Thomas M.
Year: 1987
Title: Flight simulator training effectiveness research in U. S. Army aviation
Conference Name: The Acquisition and Use of Flight Simulation Technology in Aviation Training: International Three Day Conference
Conference Location: London?
Date: April 27-29

Author's Title and Affiliation: Army Research Institute, Aviation Research & Development Activity (ARIARDA), Fort Rucker, AL
Number of Pages: 35
Keywords: flight simulator training effectiveness, cost effectiveness

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Reference Type: Journal Article
Author: Loose, Rainer; Probst, Thomas
Year: 2001
Title: Velocity not acceleration of self-motion mediates vestibular-visual interaction
Journal: Perception
Volume: 30
Pages: 511-518
Author's Title and Affiliation: Loose: Institute of Experimental Psychology, University of Regensburg, D 93040 Regensburg, Germany
Probst: Institute of Psychology, Technical University of Aachen, D 52056 Aachen, Germany
Abstract: We investigated the influence of vestibular stimulation with different angular accelerations and velocities on the perception of visual motion detection. Constant accelerations resulting in different angular velocities and constant angular velocities obtained at different accelerations were combined in twenty healthy subjects. Random-dot kinematograms with coherently moving pixels and randomly moving pixels were used as visual stimuli during whole-body rotations. The smallest percentage of coherently moving pixels leading to a clear perception of motion detection was taken as the perception threshold. Perception thresholds significantly increased with increasing angular velocity. Increased acceleration, however, had no significant effect on the perception thresholds. We conclude that the achieved angular velocity, and not acceleration, is the predominant factor in the processing of vestibular-visual interaction.

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Reference Type: Conference Proceedings
Author: Lowther, Kathy; Ware, Colin
Year of Conference: 1996
Title: Vection with large screen 3D imagery
Conference Name: CHI: Conference on Human Factors in Computing Systems
Conference Location: Vancouver, British Columbia, Canada
Publisher: Association for Computing Machinery (ACM)
Author's Title and Affiliation: Faculty of Computer Sciences, University of New Brunswick, P.O. Box 4400, Fredericton, New Brunswick, Canada E3B 5A3
Number of Pages: 4
Keywords: vection, virtual environments
Abstract: Vection is the illusory impression of self motion that can be obtained when an observer views a large screen display containing a rotating or translating pattern. To aid in our construction of an interactive large screen interface to virtual 3D environments, we conducted studies to determine the factors which induce a sense of vection. We found that having a foreground frame and a stereo display increased vection. If subjects moved when the display was being observed then vection decreased. However, if the perspective was coupled to their head position while they moved then vection was restored.
URL: http://acm.org/sigchi/chi96/proceedings/shortpap/Lowther/lk_txt.htm
Author Address: kathy@omg.unb.ca
cware@unb.ca

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Reference Type: Newspaper Article
Reporter: Lowy, Joan
Year: 2009
Title: FAA chief reluctant to raise minimum pilot hours

Newspaper: The Associated Press
City: Washington DC
Issue Date: December 10, 2009
URL: http://abcnews.go.com/Business/wireStory?id=9301107

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Reference Type: Journal Article
Author: Lu, Z-L.; Sperling, G.
Year: 1996
Title: Contrast gain control in first- and second-order motion platform
Journal: Journal of the Operational Society of America
Volume: 13
Issue: 12
Pages: 2305-2318
Date: December
Author's Title and Affiliation: Zhong-Lin Lu: Department of Psychology, University of Southern California, Los Angeles, CA 90089
George Sperling: Human Informational Processing Laboratory, Department of Cognitive Sciences and Institute for Mathematical Behavioral Sciences, University of California, Irvine, CA 92697
Number of Pages: 14
Abstract: A novel pedestal-plus-test paradigm is used to determine the nonlinear gain-control properties for the first-order (luminance) and the second-order (texture-contrast) motion systems, that is, how these systems' responses to motion stimuli are reduced by pedestals and other masking stimuli. Motion-direction thresholds were measured for test stimuli consisting of drifting luminance and texture-contrast-modulation stimuli superimposed on pedestals of various amplitudes. (A pedestal is a static sine-wave grating of the same type and same spatial frequency as the moving test grating.) It was found that first-order motion-direction thresholds are unaffected by small pedestals, but at pedestal contrasts above 1-2% (5-10x pedestal threshold), motion thresholds increase proportionally to pedestal amplitude (a Weber law). For the first-order stimuli, pedestal masking is specific to the spatial frequency of the test. On the other hand, motion-direction thresholds for texture-contrast stimuli are independent of pedestal amplitude (no gain control whatever) throughout the accessible pedestal amplitude range (from 0 to 40%). However, when *baseline carrier* contrast increases (with constant *pedestal modulation* amplitude), motion thresholds increase, showing that gain control in second-order motion is determined not by the modulator (as in first-order motion) but by the carrier. Note that baseline contrast of the carrier is inherently independent of spatial frequency of the modulator. The drastically different gain-control properties of the two motion systems and prior observations of motion masking and motion saturation are all encompassed in a functional theory. The stimulus inputs to both first- and second-order motion process are normalized by feedforward, shunting gain control. The different properties arise because the modulator is used to control the first-order gain and the carrier is used to control the second-order gain.

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Reference Type: Journal Article
Author: Lu, Zhong-Lin; Sperling, George
Year: 2001
Title: Three-systems theory of human visual motion perception: Review and update
Journal: Journal of the Optical Society of America
Volume: 18
Issue: 9
Pages: 2332-2370
Date: September
Author's Title and Affiliation: Lu: Laboratory of Brain Processes, Department of Psychology, University of Southern California, Los Angeles, California 90089-1061
Sperling: Human Information Processing Laboratory, Departments of Cognitive Sciences and Neurobiology and Behavior, and Institute of Mathematical Behavioral Sciences, University of California, Irvine, Irvine, California 92697

Keywords: vision, color, visual optics, motion detection
Abstract: Lu and Sperling [Vision Res. 35, 2697 (1995)] proposed that human visual motion perception is served by three separate motion systems: a first-order system that responds to moving luminance patterns, a second-order system that responds to moving modulations of feature types—stimuli in which the expected luminance is the same everywhere but an area of higher contrast or of flicker moves, and a third-order system that computes the motion of marked locations in a ''salience map,'' that is, a neural representation of visual space in which the locations of important visual features (''figure'') are marked and ''ground'' is unmarked. Subsequently, there have been some strongly confirmatory reports: different gain-control mechanisms for first- and second-order motion, selective impairment of first- versus second- and/or third-order motion by different brain injuries, and the classification of new third-order motions, e.g., isoluminant chromatic motion. Various procedures have successfully discriminated between second- and third-order motion (when first-order motion is excluded): dual tasks, second-order reversed phi, motion competition, and selective adaptation. Meanwhile, eight apparent contradictions to the three-systems theory have been proposed. A review and reanalysis here of the new evidence, pro and con, resolves the challenges and yields a more clearly defined and significantly strengthened theory.
URL: http://lobes.usc.edu/Journals/JOSAA01LuSperling.pdf

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Reference Type: Conference Paper
Author: Luijt, Ralph S.; Van de Moesdijk, Gerrit A.J.
Year: 1992
Title: Some considerations for the definition of motion cue validation tests
Conference Name: European Forum on Matching Technology to Training Requirements
Publisher: Royal Aeronautical Society
Date: May

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Reference Type: Conference Paper
Author: Lusk, Steven L.; Martin, Cynthia D.; Whiteley, James D.; Johnson, William V.
Year: 1990
Title: Time delay compensation using peripheral visual cues in an aircraft simulator
Conference Name: AIAA Flight Simulation Technologies Conference
Conference Location: Atlanta, GA
Publisher: American Institute of Aeronautics and Astronautics (AIAA)
Date: September 7-9
Electronic Resource Number: AIAA-90-3129-CP
Author's Title and Affiliation: Lusk : Logicon Technical Services Inc.
Martin : University of Dayton Research Institute
Whiteley : Armstrong Aerospace Medical Research Laboratory
Johnson : Systems Research Laboratories, Inc.
Number of Pages: 8
Abstract: The effects of simulator time delays on performance, control behavior and transfer of training were investigated using supplementary peripheral visual cueing. A disturbance-regulation task was used in which subjects were instructed to maintain a particular heading and altitude in the presence of pseudo-random wind gusts. The experiment took place in a fixed-base simulator with fighter-type dynamics. Delays used for the primary visual display were 67 and 300 ms. The peripheral horizon displays were either matched to the primary display, mismatched, or not present at all. Respectively, the four combinations of primary and peripheral display delays investigated were: (1) 67 ms/ 67 ms, (2) 300 ms/ 67 ms, (3) 300 ms/ 300 ms, and (4) 300 ms/ no peripheral display. Subjects trained in one of these four conditions for 50 trials. At the end of training, subjects in the matched, minimal delay condition (67 ms/ 67 ms) maintained heading significantly better ($p<.05$) than subjects in each of the other three conditions. Thus, delayed primary cues did degrade performance. However, subjects with delayed primary cues and matched or mismatched peripheral cues (conditions 2 and 3) did not perform significantly better than subjects with delayed primary cues and no peripheral display (condition 4). This suggests that

supplementary peripheral cueing, matched or mismatched, was not able to adequately compensate for the unresponsiveness of the simulated aircraft. There were no significant differences among the groups at transfer (trial 51).

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Reference Type: Journal Article
Author: Macchiarella, Nikolas; Brady, Tim; Lyon, Brandon S.
Year: 2008
Title: An application of high fidelity FTDs for ab initio pilot training: The way ahead
Journal: Collegiate Aviation Review
Volume: 26
Issue: 1
Pages: 67-77
ISSN: 1523-5955
Number of Pages: 11
Accession Number: 01114047
Keywords: costs, education and training methods, flight simulators, flight training, general aviation, simulation
Abstract: Decreases in simulation costs and increases in aircraft training costs led to the need for further investigation into the application of simulation-based training. Researchers conducted an 18-month study using ab initio student pilots as participants. This study applied a Federal Aviation Administration approved, Part 142, flight-training curriculum that included 60% flight training device use. Researchers identified 5 causal factors that warranted further investigation: visual fidelity, procedural similarity, dynamic flight environment, difficulty of task, and visual scanning and response. These causal factors have the potential to affect transfer of training from simulated flight to aircraft flight. Steps are being taken to optimize training while considering the causal factors.

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Reference Type: Conference Paper
Author: Macchiarella, Nickolas D.
Year: 2008
Title: Advancements in flight training devices for ab initio pilot use
Conference Name: AIAA Modeling and Simulation Technologies Conference and Exhibit
Conference Location: Honolulu, HI
Publisher: American Institute of Aeronautics and Astronautics (AIAA)
Date: 8/18/2008-8/21/2008
Author's Title and Affiliation: Nickolas D. Macchiarella, Associate Professor at Embry-Riddle Aeronautical University, member of Aeronautical Science, Flight Test and Simulation, AIAA
Number of Pages: 9
Abstract: Ab Initio pilot training centers have access to Flight Training Devices (FTD) that can serve as an effective medium for training student pilots. This training includes tasks necessary for certification during visual meteorological conditions (VMC). High fidelity FTDs have visual systems, control loading, and aerodynamic modeling that were previously unavailable in FAA qualified FTDs. However, due to the recency of higher levels of fidelity in FTDs there is an opportunity to refine the devices in terms of perceptual fidelity and behavioral fidelity. Embry-Riddle Aeronautical University conducted a two-year transfer of training (ToT) study in an effort to quantify the effects of training in an FTD for private pilot certification. Analyses of data led researchers to conclusions addressing modification of visual systems and the creation of a virtual air traffic (VAT) functionality. VAT will integrate voice and event triggered virtual air traffic control and air traffic into the FTD virtual environment with the goal of increasing realism.

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Reference Type: Journal Article
Author: Macchiarella, Nickolas D.; Arban, Pamela K.; Doherty, Shawn M.
Year: 2006
Title: Transfer of training from flight training devices to flight for ab-initio pilots
Journal: International Journal of Applied Aviation Studies
Volume: 6

Issue: 2
Pages: 299-314
Author's Title and Affiliation: Embry-Riddle Aeronautical University
Number of Pages: 16
Keywords: transfer of training (ToT), ab-initio training, flight training device (FTD)
Abstract: The application of flight simulation to meet pilot training needs continues to evolve. Flight simulations built with powerful and inexpensive computers are making high fidelity simulation available as a medium for training ab-initio pilots at Pilot Schools and Training Centers. The researchers conducted an 18-month study that applied an experimental flight-training curriculum comprised of 60% flight training device (FTD) flight and 40% airplane flight to certify Private Pilots under Federal Aviation Regulation (FAR) Part 142. The results from the research provided data to ascertain the effective transfer for each flight-training task. Ab-initio student pilots practiced each task to standard in an FTD prior to training in an actual airplane. The researchers measured a significant degree of effective transfer for the majority of flight tasks examined.
URL:
http://www.faa.gov/about/office_org/headquarters_offices/arc/programs/academy/journal/pdf/Fall_2006.pdf
Author Address: Embry-Riddle Aeronautical University, 600 S. Clyde Morris Blvd., Daytona Beach, FL 32114-3900

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Reference Type: Conference Paper
Author: Macchiarella, Nickolas D.; Doherty, Shawn M.
Year: 2007
Title: High fidelity flight training devices for training ab initio pilots
Conference Name: The Interservice/Industry Training, Simulation & Education Conference (I/ITSEC)
Abstract: An experimental flight training program at Embry-Riddle Aeronautical University (ERAU) investigated the degree to which flight simulation could be used in a training curricula for ab initio pilots. The experimental group earned an FAA private pilot's certificate using a curriculum largely comprised of simulated flight in flight training devices (FTD); the control group trained exclusively in airplanes. What sets this research apart from prior transfer of training (ToT) work is the high level of simulator usage, (60% FTD-based flight) and the FAA's approval for certifying pilots with this methodology. Researchers hypothesized that optimizing the application of specifically designed FTDs will afford the simulation related training benefits typically associated with more costly "graduate level" flight training (e.g., the FAA's Advanced Qualification Program [AQP] and military advanced aircraft type ratings) to ab initio flight training for a relatively low cost. At the core of this research investigation was a classic transfer of training (ToT) study examining 34 flight tasks. Transfer can be measured using the transfer effectiveness ratio (TER) equation. The results from the amount of transfer from the FTD to actual aircraft flight suggested implications for both adjustments to the flight training curricula and for specific modifications to the FTD as applied in an ab-initio training program. More specifically, these results provided an indication that added visual fidelity, in terms of graphical 3D artwork, was necessary in the virtual environment for particular ground reference maneuver tasks. A low fidelity visual scene at low level flight altitudes provided poor cues for pilots training for ground reference maneuvers. Additionally, the level of traffic in the scenario and degree of complexity in simulated airspace affected transfer to the real world flights.

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Reference Type: Report
Author: Macchiarella, Nickolas D.; Kring, Jason
Year: 2009
Title: Synthetic voice in the cockpit research
City: Daytona Beach, FL
Institution: Embry-Riddle Aeronautical University
Pages: 1-5
Date: 08/26

Type: White Paper
Author's Title and Affiliation: Nickolas D. Macchiarella, Ph.D., Aeronautical Science Department at Embry-Riddle Aeronautical University
Jason Kring, Ph.D., Embry-Riddle Aeronautical University
Number of Pages: 5
Author Address: Nickolas D. Macchiarella
Embry-Riddle Aeronautical University
Aeronautical Science Department
600 South Clyde Morris Boulevard
Daytona Beach, FL 32114-3900

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Reference Type: Book Section
Author: Mack, A.
Year: 1986
Title: Perceptual aspects of motion in the frontal plane
Editor: Boff, K.; Kaufman, L.; Thomas, J.
Book Title: Handbook of Perception and Human Performance: Sensory Processes and Perception
City: New York
Publisher: John Wiley and Sons
Volume: 1
Number of Volumes: 2
Pages: 117-126
Edition: 1

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Reference Type: Journal Article
Author: MacKay, Donald G.
Year: 1982
Title: The problems of flexibility, fluency, and speed-accuracy trade-off in skilled behavior
Journal: Psychological Review
Volume: 89
Issue: 5
Pages: 483-506
Author's Title and Affiliation: Department of Psychology, University of California, Los Angeles
Abstract: With patience, behavior sequences become more fluent (faster, less prone to error). The present article reviews existing theories of practice and proposes a new theory that better accounts for how people become more fluent in high-proficiency skills such as speech production. Under the theory, execution of behavior involves the activation of a hierarchy of notes in proper serial order within an output system. Activating a node at any level in the system primes or partially activates its connecting nodes, and practice or repeated activation increases the rate of priming per unit of time, thereby allowing a faster rate of output at the lowest muscle movement level. Relevance of the theory for several related issues is discussed: why behavior becomes more flexible with practice, transferring readily from one response mechanism to another; why there is almost perfect transfer from one hand to the other for simple skills such as Morse key tapping or moving chess pieces, but less than perfect transfer for complex skills such as handwriting with the unaccustomed hand; why skills at higher, "semantic" levels transfer to new behavioral sequences, as when bilinguals produce a word-for-word translation of a practiced sentence in their other language. The theory also provides a new way of looking at motor equivalence, automaticity, speed-accuracy trade-off, subordinate autonomy, and the motor program.
Author Address: Department of Psychology, University of California, Los Angeles, CA, 90024

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Reference Type: Electronic Article
Author: Maeda, Fumiko; Kanai, Ryota; Shimojo, Shinsuke
Year: 2004
Title: Changing pitch induced visual motion illusion
Periodical Title: Current Biology
Volume: 14
Issue: 23
Pages: 990-991
URL: http://www.sciencedirect.com/science?_ob=ArticleURL&_udi=B6VRT-4F13RF4-6&_user=645219&_rdoc=1&_fmt=&_orig=search&_sort=d&_docanchor=&view=c&_acct=C000034688&_version=1&_urlVersion=0&_userid=645219&md5=3ae1f8ddf02f8ac8a165d4caa3a44721
Access Date: July 20, 2007

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Reference Type: Conference Paper
Author: Magee, L. E.; Kantor, L.; Sweeney, D. M. C.
Year: 1987
Title: Simulator induced sickness among Hercules aircrew
Conference Name: Aerospace Medical Panel Symposium on Motion Cues in Flight Simulation and Simulator Induced Sickness
Conference Location: Brussels, Belgium
Publisher: Advisory Group for Aerospace Research and Development (AGARD)
Date: September 29
Author's Title and Affiliation: Defence and Civil Institute of Environment Medicine, 1133 Sheppard Ave. West, Downsview, Ontario, M3M 3B9 Canada
Number of Pages: 7
Keywords: simulator induced sickness, Hercules aircrew, motion, vision, symptoms
Abstract: The purposes of this study were to investigate the incidence, severity and time course of simulator sickness among pilots and flight engineers training on a C-130H(Hercules) flight simulator, and to assess the influence of flight experience on susceptibility. Evidence of simulator sickness was collected by questionnaire, tests of balance, and observation. The questionnaires were completed at the conclusion of a four-hour training session and 20 hours later. The balance tests were performed immediately prior and immediately following the training session. Overt signs of pallor, sweating, drowsiness and visual nystagmus were also recorded at these times. Thirty-five of the 42 aircrew (i.e. 83 %) tested reported characteristic symptoms of simulator sickness. The most prevalent were eyestrain, mental and physical fatigue, and after-sensations of motion. Some effects persisted following simulator training for many hours although most were not severe. Few had delayed onset. Although eleven subjects (26%) reported loss of balance at the end of the training session, performance on the balance tests improved; this suggests a practice effect which masks ataxia. With the exception of occasional nystagmus, no overt signs of simulator sickness were evident. The relationship between aircraft experience, both general and type-specific, and diagnostic scores based on symptoms were examined. There was no evidence to indicate that experience influenced susceptibility to simulator sickness.
URL: http://stinet.dtic.mil/oai/oai?verb=getRecord&metadataPrefix=html&identifier=ADA202492

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Reference Type: Conference Paper
Author: Manville, P.; Whybray, E. D.
Year: 1978
Title: Low budget simulation in weapons aiming
Conference Name: Flight Mechanics Panel Specialists' Meeting on Piloted Aircraft Environment Simulation Techniques
Conference Location: Brussels, Belgium
Publisher: Advisory Group for Aerospace Research and Development (AGARD)
Date: April 24-27

Author's Title and Affiliation: Royal Aircraft Establishment
Number of Pages: 8
Keywords: low budget simulation, weapons aiming
Abstract: For a number of years the Flight Systems Department at RAE Farnborough has been effectively operating and developing a low budget research simulator, designed to explore aiming sequences, accuracies and real time usage in air-to-ground weapon delivery from low altitude.
Work completed has shown the value of this basic facility in providing fundamental data for assessment purposes and for the optimization of pilots' tasks.
As a result, the simulator has been expanded to permit the aiming sequences of air-to-air combat and air-to-ground designators to be evaluated.
The description of the techniques and equipment employed illustrate how accuracy and fidelity can be achieved within modest resources.

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Reference Type: News Release
Author: Marketwire
Year: 2009
Title: Scalable display technologies delivers on contract for U.S. coast guard aircrew training simulator
Place Published: Cambridge, MA and Orlando, FL
Date: November 30
Keywords: Coast Guard Aircrew Weapons Trainer, multi-projector display systems, EasyBlend calibration software, simulator training device, motion base
Abstract: Scalable Display Technologies, a leading provider of software for multi-projector display systems, today announced the installation of its EasyBlend(TM) software in an aircrew weapons training simulator for the U.S. Coast Guard. Pathfinder Systems, which specializes in the management and execution of U.S. government contracts, led the project to develop the Coast Guard Aircrew Weapons Trainer (CGAWT) in support of the U.S. Coast Guard's helicopter aircrew weapons training.
URL: http://au.sys-con.com/node/1203613
Access Date: December 1, 2009

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Reference Type: Magazine Article
Author: Marsh, Alton K.
Year: 1999
Title: In-flight emergencies: Upset recovery
Magazine: AOPA Pilot Magazine
Volume: 42
Issue Number: 8
Keywords: upset recovery training (URT)
Abstract: [first paragraph] How many times have you accidentally been upside down? Never, for most of you. It's difficult to believe it could ever happen to you. But a little ice on the wings, a lot of turbulence from an airliner, winds tumbling across mountain ranges, an autopilot gone berserk -- any of these could cause an unwelcome attitude.
URL: http://www.aopa.org/pilot/features/inflight9908.html

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Reference Type: Magazine Article
Author: Marsh, George
Year: 2003
Title: Typhoon: Europe's finest
Magazine: Avionics Magazine
Date: June 1
Keywords: Eurofighter Typhoon, carefree handling, upset recovery training (URT)

Abstract: This multinational combat aircraft represents not only Europe's best effort in air superiority, but also in fighter cockpit technology, designed to deliver extraordinary situational awareness minus an inordinate workload.
URL: http://www.aviationtoday.com/av/categories/military/917.html

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Reference Type: Conference Paper
Author: Martin, Edward
Year: 1999
Title: Motion and force simulation systems I: Whole-body motion simulation
Conference Name: The Fifteenth Annual Flight and Ground Vehicle Simulation Update
Conference Location: State University of New York at Binghamton
Date: January 11-15
Author's Title and Affiliation: Wright-Patterson Air Force Base
Number of Pages: 50

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Reference Type: Thesis
Author: Martin, Edward Albert
Year: 1985
Title: The influence of tactual seat-motion cues on training and performance in a roll-axis compensatory tracking task setting
Academic Department: Department of Biomedical Engineering
University: Ohio State University
Thesis Type: Dissertation
Author's Title and Affiliation: B.S., M.S. (EE)
Keywords: seat-motion cues, roll-axis compensatory tracking

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Reference Type: Conference Paper
Author: Martin, Edward A.
Year: 1985
Title: An investigation regarding the use of a dynamic seat-pan display for training and as a device for communicating roll-axis motion information
Conference Name: Third Symposium on Aviation Psychology
Conference Location: Aviation Psychology Laboratory, Ohio State University, Columbus
Date: April 22-25
Author's Title and Affiliation: U.S. Air Force, Aeronautical Systems Division, Wright-Patterson Air Force Base
Number of Pages: 8
Keywords: dynamic seat-pan, roll-axis motion, DSS, dynamic seat system, RATS, roll-axis tracking simulator
Abstract: This paper describes a research program conducted to determine the feasibility of providing useful angular onset-motion information via a broad-area tactual seat-pan display. The experiment was designed to permit the evaluation of the utility of the display as a training device as well as its efficacy for imparting motion information. The results indicate that--with proper attention given the drive law--the tactual display can elicit both performance and control behavior indistinguishable from that observed in a whole-body motion environment. Unfortunately, the training transfer results were not so encouraging. These indicated that the seat-pan display as used in this study was not adequate for training naive subjects to properly interpret and use the motion information available in a whole-body motion environment.

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Reference Type: Conference Paper
Author: Martin, Edward A.
Year: 1999
Title: Motion and force simulation systems I: Whole-body motion simulators
Conference Name: 15th Annual Flight and Ground Simulation Update
Conference Location: State University of New York at Binghamton
Date: January 11-15

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Reference Type: Report
Author: Martin, Edward A.
Year: 2007
Title: Guidance for development of a flight simulator specification
City: Wright-Patterson Air Force Base, OH
Institution: Air Force Research Laboratory
Report Number: AFRL-HE-WP-SR-2007-0002
Author's Title and Affiliation: AFRL/HECS
Cognitive Systems Branch
2255 H Street, Bldg 248
Wright-Patterson AFB, OH 45433-7022
Recipient's Title and Affiliation: Air Force Material Command
Air Force Research Laboratory
Human Effectiveness Directorate
Warfighter Interface Division
Cognitive Systems Branch
Wright-Patterson AFB, OH 45433-7022
Keywords: engineering specification, flight simulator specification guidance
Abstract: A long-standing problem in the acquisition of flight simulators has been the clear communication of requirements through the specification process. There are numerous reasons for this, including obfuscation by technical jargon, fragmentation of requirements within a specification, and a human inclination to adopt 'cut and paste' approaches which may reflect the requirements of a precedent system more than those of the current system. In an attempt to address these problems, this document was developed as basis for a tool in the form of a generic flight simulator specification that will guide specification development for a diverse range of flight simulator applications. Each generic specification paragraph includes recommendations and rationale for specification language, verification, and options. Guidance reflects the requirements established by civil regulatory agencies—such as the International Civil Aviation Organization's criteria for the qualification of flight simulators—as well as those unique requirements related to military applications. This generic guidance specification is embodied in a software format that makes it relatively easy to use—so as to encourage its use. When it is used, the documents produced will reflect the high degree of standardization imposed by this guidance specification. It will provide a clear alternative to less-disciplined cut-and-paste approaches. Standardized format and vocabulary will help avoid misplaced information and inconsistent interpretations. Localization and integration of requirements will minimize conflicts.
URL:
http://www.aiaa.org/Participate/Uploads/Flight%20Simulator%20Specification%20%282007%29%2Edoc

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Reference Type: Conference Paper
Author: Martin, Edward A.; Brett, Bryan E.; Hoagland, David G.
Year: 1999
Title: Tools for including realistic representations of operator performance in DoD constructive simulations
Conference Name: AIAA Modeling and Simulation Technologies Conference and Exhibit

Conference Location: Portland, OR
Publisher: American Institute of Aeronautics and Astronautics (AIAA)
Date: August 9-11
Electronic Resource Number: AIAA-99-4027
Author's Title and Affiliation: Martin - Crew System Interface Division Airforce Research Laboratory
Brett - Science Application International Company
Hoagland - Crew System Interface Division Airforce Research Laboratory
Number of Pages: 9
Abstract: Military weapon systems are normally built to satisfy a set of requirements levied by the warfighter. All these weapon systems are manned in some sense, yet tools for quantifying the effectiveness with which a crewstation must support operator performance are lacking. Analysts and decision-makers need a means to readily model and understand the effects of human performance on total weapon system effectiveness when translating operational requirements into system requirements. This paper discusses the research and demonstration activities being conducted by the Combat Automation Requirements Testbed (CART) Program within the Air Force Research Laboratory / Human Effectiveness Directorate. CART will demonstrate how human-in-the-loop and constructive operator models and data can be integrated with Simulation-Based Acquisition activities for the purpose of defining crewstation requirements. Utilizing the Army's IMPRINT human-performance modeling environment, CART will provide High Level Architecture (HLA) interfaces that enable human-performance models to interact with constructive models of systems. A second extension will incorporate the ability to represent the goal-oriented nature of human performance. Modelers and analysts will be able to define operator goal states and priorities that dynamically drive task network models based on changing states and events in simulated military environments.
URL: http://handle.dtic.mil/100.2/ADA430277

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Reference Type: Conference Proceedings
Author: Martin, Edward A.; Osgood, Robert K.; McMillan, Grant R.
Year of Conference: 1987
Title: The dynamic seat as an onset cuing device
Conference Name: AIAA Flight Simulation Technologies Conference
Conference Location: Monterey, CA
Publisher: American Institute of Aeronautics and Astronautics (AIAA)
Pages: 1-8
Date: August 17-19
Electronic Resource Number: 87-2438-CP
Author's Title and Affiliation: Martin: Ph.D., ASD/ENETA, Wright-Patterson AFB, OH 45433-6503
Osgood: Ph.D., Systems Research Laboratories, Dayton, OH 45440
McMillan: Ph.D., AAMRL/HEF, Wright-Patterson AFB, OH 45433-6503
Number of Pages: 7
Keywords: dynamic seat, offset cueing device, g-seats, ALCOGS, RATS
Abstract: The research described in this paper deals with an evaluation of advanced dynamic seats as an alternative to platform motion simulation. The dynamic seat has been shown to be an effective device for providing task-critical onset motion information, provided that proper attention is given to the drive laws. Its value as a training device remains equivocal, however; additional research is required to address this training issue.
It is difficult to extrapolate the benefit derived from dynamic seat cuing in laboratory tracking tasks to the operational task environment. An evaluation of the dynamic seat within the context of a more operationally-realistic task environment is necessary. The task chosen for this evaluation is aerial refueling. This paper discusses a brief series of experiments initiated to develop the drive laws for additional angular and linear degrees-of-freedom that become necessary with a multi-axis control task like aerial refueling.

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Reference Type: Report
Author: Martin, Elizabeth L.
Year: 1981
Title: Training effectiveness of platform motion: Review of motion research involving the advanced simulator for pilot training and the simulator for air-to-air combat
City: Brooks Air Force Base, TX
Institution: Air Force Human Resources Laboratory
Date: February
Type: Final Report
Report Number: AFHRL-TR-79-51
Author's Title and Affiliation: Operations Training Division, Williams Air Force Base, AZ 85224
Recipient's Title and Affiliation: Air Force Human Resources Laboratory, Brooks Air Force Base, TX 78235
Number of Pages: 29
Keywords: platform motion, transfer of training, training effectiveness, flight simulator, flying training, Advanced Simulator for Pilot Training (ASPT), Simulator for Air-to-Air Combat (SAAC), motion simulation
Abstract: This report presents a summary review of the transfer-of-training studies conducted by the Operations Training Division of the Air Force Human Resources Laboratory investigating the training effectiveness of six-degrees-of-freedom platform motion cueing. A total of six studies are reviewed. Of the six studies, five were conducted on the Advanced Simulator for Pilot Training (ASPT) located at Williams AFB and one on the Simulator for Air-to-Air Combat (SAAC) located at Luke AFB. Tasks investigated included basic and advanced contact, instruments, basic fighter maneuvers, and conventional weapons delivery. The review of each study contains a statement of objectives, a summary of the method and results, a data excerpt representative of the findings, and a critique. The report also contains a description of the research strategy from which the studies were derived, a discussion of transfer-of-training methodology, and a discussion of the relationship between the results of these six studies and research findings from other agencies or facilities. Implications for future research are discussed.

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Reference Type: Conference Paper
Author: Mathews, R. H.
Year: 1978
Title: Manned air combat simulation: A tool for design, development and evaluation for modern fighter weapon systems and training of aircrews
Conference Name: Flight Mechanics Panel Specialists' Meeting on Piloted Aircraft Environment Simulation Techniques
Conference Location: Brussels, Belgium
Publisher: Advisory Group for Aerospace Research and Development (AGARD)
Date: April 24-27
Author's Title and Affiliation: Chief, Flight Simulation, Flight Simulation Department, McDonnell Aircraft Company, A Division of McDonnell Douglas Corporation
Number of Pages: 6
Keywords: manned air combat, simulation, aircrew training
Abstract: Manned Aircraft combat simulation has matured into a major element in modern fighter aircraft design and development. The simulation fidelity now available allows meaningful training to be accomplished such that U.S. Government is now procuring an Air Combat Maneuvering Simulator (ACMS) for fighter tactics training. This paper describes the contributions of manned air combat simulation to the F-15 fighter weapon systems from design concept through successful introduction to squadron service. Specific examples are given of airframe avionics, and integrated systems simulation support in the design and development process. A comparison of flight simulation results in several test programs included in air combat maneuvering is presented. Additionally, a description is presented of the Air Combat Maneuvering Simulator (ACMS Device 2E6) being provided to the U.S. Navy for air combat training.

Reference Type: Conference Paper
Author: Matthews, N. O.; Martin, C. A.
Year: 1978
Title: The development and evaluation of a "g" seat for a high performance military aircraft training simulator
Conference Name: Flight Mechanics Panel Specialists' Meeting on Piloted Aircraft Environment Simulation Techniques
Conference Location: Brussels, Belgium
Publisher: Advisory Group for Aerospace Research and Development (AGARD)
Date: April 24-27
Author's Title and Affiliation: Cranfield Institute of Technology, Cranfield, Bedford, England, MK43 OAL
Keywords: g -seats
Abstract: Early 'g' seats fitted in British Military training simulators had been unsatisfactory in that they produced incorrect and, in some cases, negative cues to the pilots and, in addition, were incapable of providing simulated steady 'g' cues.
The program of development work described in this paper will cover the examination of the original type of seat and attempts to improve its performance leading to the design of a completely new concept in simulator 'g' seats. The philosophy behind the changes in the design will be considered and the implementation of these in terms of hardware will be described.
Tests of the prototype model of the new seat have been carried out in conjunction with a 3-axis motion system of improved performance characteristics at Cranfield Institute of Technology and the results of evaluations by a number of service test pilots and pilots will be described.
The seat has now been accepted for installation in a service training simulator for the next generation of high performance aircraft.

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Reference Type: Conference Paper
Author: Matton, Joseph S.
Year: 1996
Title: Principles and technologies for reengineering pilot training
Conference Name: AIAA Flight Simulation Technologies Conference
Conference Location: San Diego, CA
Publisher: American Institute of Aeronautics and Astronautics (AIAA)
Date: July 29-31
Electronic Resource Number: AIAA-1996-3525
Author's Title and Affiliation: USAF, Armstrong Lab., Mesa, AZ
Abstract: Computer hardware and software technology has advanced far more rapidly than principles for guiding its application to aviation training. Technological capabilities will not increase the effectiveness or efficiency of training unless the structure and processes of current training programs are changed, and the specific potentialities of information technology are matched to student learning needs. Reengineering principles have been successful for increasing efficiency and productivity within business and industry and can be applied to the task of integrating new technologies within existing training programs. When combined with well-established findings of learning and training research, the reengineering of pilot training processes can successfully tap the power of new technologies to produce overall improvements in pilot training.
Computer hardware and software technology has advanced far more rapidly than principles for guiding its application to aviation training. For example, we are now able to simulate many types of flight environments with a great deal of accuracy and realism and record the actions, decisions, and behavior of pilots and aircrew in real time, but these new capabilities do not guarantee effective training. Part of the problem is due to older training models and strategies that were produced for a different type of economy with different constraints and limitations. Misconceptions and overgeneralizations of psychological principles of learning and educational research have also resulted in suboptimal training technology. Technologies, applied research, and reengineering principles should be combined to provide for a robust integration of technology rather than simply embellishing or automating parts of the existing training program.

Reference Type: Conference Proceedings
Author: Mayrhofer, Michael; Langwallner, Bernhard; Schlüsselberger, Richard; Bles, Willem; Wentink, Mark
Year of Conference: 2007
Title: An innovative optimal control approach for the next generation simulator motion platform DESDEMONA
Conference Name: AIAA Modeling and Simulation Technologies Conference and Exhibit
Conference Location: Hilton Head, SC
Publisher: American Institute of Aeronautics and Astronautics (AIAA)
Date: August 20-23
Electronic Resource Number: AIAA 2007-6474
Author's Title and Affiliation: Mayrhofer: Project Manager, Research and Development, AMST Systemtechnik GmbH, Lamprechtshausenerstrasse, P.O. Box 3, 5282 Ranshofen, Austria
Langwallner: Researcher, Research and Development, AMST Systemtechnik GmbH, Lamprechtshausenerstrasse, P.O. Box 3, 5282 Ranshofen, Austria
Schlüsselberger: CEO, AMST Systemtechnik GmbH, Lamprechtshausenerstrasse, P.O. Box 3, 5282 Ranshofen, Austria
Bles and Wentink: Project Manager, Human Factors, TNO, Kampweg 5, 3769 ZG Soesterberg, the Netherlands
Abstract: The very unique and novel motion platform DESDEMONA was taken into start-up operation early this year. The next generation motion platform allows 6-DoF movement combined with the capability of producing sustained g-forces. These features make the simulator extremely valuable for future flight simulation applications as well as for disorientation research and training. In order to use the equipment for different kinds of applications advanced motion filters have been developed. The success of Desdemona will strongly be dominated by the quality of these motion filters. In our approach efficient numerical optimization techniques are applied to gain control laws for given real acceleration profiles. Additionally human perception models can be applied and included in the optimization sequence. Two results are discussed within this paper. The first result concerns the possible improvement of 3-DoF human centrifuge profiles, when using 6-DoF Desdemona capability. The second one deals with real measured car driving data (left turn on intersection) and also includes a motion perception model. Basically, the feasibility of this approach can be confirmed and the results are promising.

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Reference Type: Conference Paper
Author: McCabe, Mark D.
Year: 1997
Title: A low cost PC-based aviation training device for IFR flight simulation
Conference Name: AIAA Modeling and Simulation Technologies Conference
Conference Location: New Orleans, LA
Publisher: American Institute of Aeronautics and Astronautics (AIAA)
Date: August 11-13
Electronic Resource Number: AIAA-1997-3514
Number of Pages: 7
Abstract: This paper describes the Jeppesen Sanderson FS-200 IFR Flight Training System. The FS-200 is an example of a new class of synthetic flight training device, the Personal Computer-Based Aviation Training Device (PCATD). Recent studies of PCATD training effectiveness show that these devices can aid teaching of instrument flight tasks at decreased cost. Qualification requirements for PCATDs and limits for authorized use of PCATDs are contained in FAA Advisory Circular (AC) 61-126. The qualification requirements of AC 61-126 and their influences on the FS-200 PCATD design are discussed.

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Reference Type: Electronic Article
Author: McCartney, Scott
Year: 2007
Title: Airlines lower bar to fill pilot ranks
Periodical Title: Wall Street Journal Online
Issue: December 18
Pages: D1-
Abstract: Worsening shortages force some small carriers to hire younger, less-experienced fliers; raising the retirement age.
URL: http://online.wsj.com/article/SB119793945130135545.html?mod=mostpop
Access Date: 12/20/07

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Reference Type: Edited Book
Editor: McCauley, Michael E.
Year: 1984
Title: Research issues in simulator sickness
Series Title: Research Issues in Simulator Sickness: Proceedings of a Workshop
City: Washington, DC
Publisher: National Academy Press
Author's Title and Affiliation: Naval Postgraduate School, Monterey, CA
Committee on Human Factors, Commission on Behavioral and Social Sciences and Education, National Research Council
Keywords: motion sickness, sensory conflict, human factors research, vestibular, vision
Abstract: Simulator sickness, with symptoms similar to motion sickness, occurs frequently in military and civilian flight trainers. Simulator sickness appears to be independent of whether a fixed base or moving base simulator is used. Methods for amelioration are described as well as recommendations for future research to develop countermeasures.

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Reference Type: Report
Author: McCauley, Michael E.
Year: 2006
Title: Do Army helicopter training simulators need motion bases?
Institution: U.S. Army Research Institute for the Behavioral and Social Sciences
Pages: 1-42
Date: February
Report Number: Technical Report 1176
Author's Title and Affiliation: Naval Postgraduate School, Operations Research Department, 1411 Cunningham Road, Room 213, Monterey, CA 93943
Number of Pages: 42
Keywords: flight simulation, flight simulators, flight training, helicopter simulators, simulator motion, Perceptual Control Theory, transfer of training
Abstract: This report reviews the arguments and the evidence regarding the need for simulator motion bases in training helicopter pilots. It discusses flight simulators, perceptual fidelity, history of motion bases, disturbance versus maneuver motion, human motion sensation, and reviews the empirical evidence for the training effectiveness of motion bases. The section on training effectiveness reviews research from relevant sources, including: Military helicopter, military transport, commercial airlines, general aviation, fighter, and attack aircraft. In addition the author describes a Perceptual Control Theory approach to determining the information requirements for simulator-based training. The author concludes that there is a substantial body of data to support the training effectiveness of flight simulation in general; that there is virtually no evidence to support the training effectiveness of motion platforms; that motion contributes to in-simulator performance, particularly for experienced pilots; that motion cues may be beneficial for flight training in unstable aircraft and in tasks involving disturbance cues, although the

evidence is weak; and that motion, noise, and vibration contribute to the realism of the simulation and, therefore, strongly influence the acceptance of a simulator by the pilot community. There is no reliable evidence that a motion base prevents simulator sickness. Instructional design is more important than physical fidelity for training effectiveness.
URL: http://stinet.dtic.mil/cgi-bin/GetTRDoc?AD=ADA444549&Location=U2&doc=GetTRDoc.pdf
Access Date: July 27, 2007

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Reference Type: Conference Proceedings
Author: McCauley, Michael E.; Hettinger, Lawrence J.; Sharkey, Thomas J.; Sinacori, John B.
Year of Conference: 1990
Title: The effects of simulator visual-motion asynchrony on simulator induced sickness
Conference Name: AIAA Flight Simulation Technologies Conference and Exhibit
Conference Location: Dayton,OH
Publisher: American Institute of Aeronautics and Astronautics (AIAA)
Date: Sept 17-19
Electronic Resource Number: AIAA-1990-3172
Author's Title and Affiliation: McCauley, Hettinger & Sharkey: Monterey Technologies, Inc., Carmel, CA
Sinacori: John B. Sinacori Associates, Pebble Beach, CA
Number of Pages: 8
Keywords: simulator visual-motion asynchrony, simulator induced sickness, vertical motion simulator
Abstract: A program of experimental research on simulator induced sickness is in progress at the Army Crew Station Branch and the Development Branch at NASA Ames Research Center. The first of a series of studies investigated the relationship between dynamics implied by the visual system and delivered by the motion base. Forty-eight Army rotorcraft pilots flew the NASA Vertical Motion Simulator (VMS) in four consecutive 10-minute segments of increasing maneuverability while assigned to one of four conditions of motion. Simulator sickness was found in all motion conditions. It increased with exposure time and maneuvering level. Differences between the four motion conditions were not statistically significant given the individual differences in susceptibility.

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Reference Type: Journal Article
Author: McCauley, M. E.; Sharkey, T. J.
Year: 1992
Title: Cybersickness: Perception of self-motion in virtual environments
Journal: Presence: Teleoperators and Virtual Environments
Volume: 1
Issue: 3
Pages: 311-318
ISSN: 1054-7460
Author's Title and Affiliation: Monterey Technologies, Inc., Cary, North Carolina 27511
Number of Pages: 8
Abstract: Human perceptual systems have evolved to provide accurate information about orientation and movement through the environment. However, these systems have been challenged in the past century by modern transportation devices and will be further challenged by visual environments (VEs) and teleoperator systems. Illusory self-motion within a VE ("cyberspace") will be entertaining and instructive, but for many users it will result in motion sickness ("cybersickness"). Sensory conflict theory and the poison hypothesis provide an unproven theoretical foundation for understanding the phenomenon. Although no single solution is likely, the problem can be contained by a combination of engineering design, equipment calibration, and exposure management.

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Reference Type: Magazine Article
Author: McClellan, J. Mac
Year: 2008
Title: New Gulfstream G650
Magazine: Flying Magazine
Date: May 22
Keywords: Gulfstream G650, fly-by-wire (FBW), upset recovery training (URT)
Abstract: Biggest, longest range and fastest business jet yet. What else would you expect?
URL: http://www.flyingmag.com/turbine/947/new-gulfstream-g650.html

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Reference Type: Report
Author: McDaniel, W. C.; Scott, P. G.; Browning, R. F.
Year: 1983
Title: Contribution of platform motion simulation in SH-3 helicopter pilot training
City: Orlando, FL
Institution: Department of the Navy, Training Analysis and Evaluation Group
Report Number: Technical Report 153
Keywords: flight training, motion, operational effectiveness, platforms, flight simulators, fighter aircraft, military aircraft, skills, training devices, performance (human), performance (engineering), pilots, teaching methods, regression analysis, helicopters, proficiency, learning, job analysis, structural engineering, transfer of training
Abstract: A number of simulation features have been incorporated into military flight simulators in the belief that they add to the realism and, therefore, increase the training value (e.g., G-suit and G-seat simulation, visual dimming to simulate Gs). Motion simulation has been in this category; however, transfer of training studies have generally yielded inconclusive answers or lack of positive training value of motion for both multi-engine and fighter/attack simulators. Few studies have addressed the contribution of motion simulation to the training of helicopter pilots. This is the second in a series of four studies designed to assess the training effectiveness of the Device 2F64C, SH-3 helicopter flight simulator. The overall program is concerned with evaluating the training effectiveness of the device in various configurations. The present study was concerned with: assessing the contribution of motion simulation to the training of helicopter fleet replacement pilots; assessing the engineering fidelity of the motion platform concurrent with the study to insure that it was performing to design specifications; and identifying variables that are predictive of training success in fleet replacement training environment.

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Reference Type: Conference Proceedings
Author: McFarland, R. E.
Year of Conference: 2001
Title: Adjustable limiting algorithms for robust motion simulation
Conference Name: AIAA Modeling and Simulation Technologies Conference and Exhibit
Conference Location: Montreal, Canada
Publisher: American Institute of Aeronautics and Astronautics (AIAA)
Date: August 6-9
Electronic Resource Number: AIAA-2001-4305
Author's Title and Affiliation: Research Engineer, Aerospace Simulation Operations Branch, NASA Ames Research Center
Abstract: Motion-based aircraft simulators use washout filters to suppress sustained motion. However, these filters occasionally produce dynamics requiring assistance from limiting algorithms to constrain a simulator to electrical and physical limits. These limiting algorithms should minimally interfere with "normal simulator operations" using washout filters, while ensuring that physical and electrical boundaries are not transcended. In addition, these algorithms should provide an adjustable relationship between efficiency during normal operations and comfort during limiting. Under the assumption that limiting is implemented using linear, second order filters, all coefficients may be determined by the selection of a single

normalized parameter per axis, along with the axis' hard limits. The relationships that unify washout and limiting filters are called "Adjustable Limiting Algorithms for Robust Motion Simulation" (ALARMS). These algorithms produce a robust interface while establishing efficiency metrics for motion cues relative to the maximum capacity of a simulator.
Author Address: NASA Ames Research Center, Moffett Field, CA 94035-1000, USA

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Reference Type: Conference Paper
Author: McGregor, D. M.
Year: 1970
Title: Some factors influencing the choice of a simulator
Conference Name: Simulation
Conference Location: Ames Research Center, Moffett Field, CA
Publisher: Advisory Group for Aerospace Research and Development (AGARD)
Date: March
Author's Title and Affiliation: National Aeronautical Establishment, National Research Council of Canada
Number of Pages: 31
Keywords: hardware, pilot tasks, motion, field-of-view, visual illustration
Abstract: This paper outlines some of the means by which the pilot derives motion information during flight and attempts to highlight some of the areas in which specific simulator characteristics are required to obtain valid results.
Discussions of several shortcomings of present hardware that must be overcome before specific tasks, such as low altitude, low speed maneuvering flight, can be simulated adequately and the difficulties of achieving a thorough understanding of the man-machine system, necessary before the simulator with just the right degree of complexity can be selected with the confidence, are presented.
Notes: Lead Discussion by J.T. Gallagher and open discussion.

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Reference Type: Conference Paper
Author: McIntyre, H. M.; Roberts, M. E. C.
Year: 1995
Title: Simulated visual scenes - Which are the critical cues?
Conference Name: AGARD FVP Symposium on "Flight Simulation -- Where are the Challenges?"
Conference Location: Braunschweig, Germany
Publisher: NASA Technical reports
Date: May 22-25
Author's Title and Affiliation: Thomson Training & Simulation Ltd, West Sussex, RH10 2RL, UK
Number of Pages: 7
Abstract: Research has shown that pilots can expect information from relatively impoverished visual scenes. However, performance of a variety of simulated flight tasks improves with greater scene complexity. Simulator visual systems cannot replicate the real world. Further, it is not possible to optimize visual system performance in all areas simultaneously. Some improvements in flight simulator visual cueing will come inevitably, as technology advances. Others present a research challenge, particularly where the likely effects of missing, contradictory or distorted information are not fully understood. These include:
The luminance dynamic range of the display; this is far less than that encountered in reality. Relative luminances between objects cannot be maintained. Luminance variations with range will therefore be distorted. Maintaining accurate color ratios at low luminances is also difficult. By careful mapping, detection ranges could be adjusted to be nominally accurate under specific conditions but not continuously accurate. The implications need to be considered carefully.
The simulation of night scenes, with some illuminated areas may require the simultaneous mixing of 2 or 3 models in the same scene, creating unusual data base management demands. This requires further investigation.

Distance judgments may be observed to be inaccurate in the simulator. To prevent this leading to degraded simulator performance and deficiencies in training it may be possible to compensate for the absence of some cues by enhancing the effect of others. Further investigation is required to establish whether such compensation is truly possible, to what degree it enhances simulator effectiveness and to identify associated costs.

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Reference Type: Magazine Article
Author: McKenna, J. T.
Year: 1999
Title: United, Pratt target simulator shortfalls
Magazine: Aviation Week & Space Technology
Pages: 64-65
Date: May 24
Keywords: upset recovery training (URT), United 747
Abstract: Heeding a study's call for high priority action, the companies plan to improve simulator fidelity. Simulators today do not portray engine malfunctions accurately.

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Reference Type: Magazine Article
Author: McKinney, Dave
Year: 2008
Title: Illusions spatial orientation and loss of control
Magazine: Business & Commercial Aviation
Date: March 1
Keywords: upset recovery training (URT), illusions, spatial disorientation
Abstract: The threat is well known to all, but it keeps killing, just the same. Recognize it and counter it, and keep the blue side up.

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Reference Type: Journal Article
Author: McLane, R. C.; Wierwille, W. W.
Year: 1975
Title: The influence of motion and audio cues on driver performance in an automobile simulator
Journal: Human Factors
Volume: 14
Issue: 5
Pages: 488-501
Author's Title and Affiliation: Virginia Polytechnic institute and State University, Blacksburg, VA
Number of Pages: 13
Abstract: A highway driving simulator with a computer-generated visual display, physical motion cues of roll, yaw, and lateral translation, and velocity-dependent sound/vibration cues was used to investigate the influence of these cues on driver performance.
Forty-eight student subjects were randomly allocated to six experimental groups. Each group of eight subjects experienced a unique combination of the motion and audio cues. The control group received a full simulation condition while each of the remaining five groups performed with certain combinations of motion and sound deleted. Each driver generated nine minutes of continuous data from which five performance measures were derived. Results indicate that the performance of yaw, lateral, and velocity deviation are significantly affected by the deletion of cues. In support of the hypothesis that driver performance is augmented by the addition of motion cues, statistically significant negative correlations were obtained between the number of motion cues present and the measures of yaw and lateral deviation. With respect to motion and audio cues, recommendations are made regarding simulator design criteria.

Reference Type: Conference Paper
Author: McMillan, Grant R.; Cardullo, Frank M.
Year: 1997
Title: System integration
Conference Name: Thirteenth Annual Flight and Ground Vehicle Simulation Update
Conference Location: State University of New York at Binghamton
Publisher: Office of Continuing Education, Watson School of Engineering, State University of New York
Date: January 13-17
Author's Title and Affiliation: McMillan: Armstrong Laboratory
Cardullo: State University of New York at Binghamton
Recipient's Title and Affiliation: Office of Continuing Education, Watson School of Engineering, State University of New York
Binghamton, New York, Phone: (607) 777-2154, Fax: (607) 777-4411
Number of Pages: 132
Abstract: These notes address the issues of cue integration and synchronization in terms of their effects on human sensation, perception and performance. Before exploring these issues, let us define a few terms. Sensation is usually defined as the process of converting or transducing physical energy into neural impulses. The energies being transformed may arise externally (e.g., light quanta) or from within the person (e.g., feedback from joint motion). Perception is typically defined as the organization of these stimuli into meaningful patterns. In the vast majority of cases the resulting percept is stable and in direct correspondence with the state of the observer and the environment. Perceptual theorists have argued that stability is maintained because the critical sensory elements do not vary from situation to situation. This leads to the integration and synchronization problem. What happens when all of the critical elements are not present? What happens when the critical sensory elements are not presented in the correct temporal sequence? As suggested above, the stability of the perceptual process will be affected. The observed effects may range from a complete absence of the desired percept, to a delayed or weak percept, or in extreme cases to severe psychological and physical discomfort. This is not meant to imply that successful simulation requires reproduction of all the physical energies produced by actual flight. Rather most perceptual theorists maintain that the critical sensory events are some subset of the real-world stimuli, or are some higher-order pattern or relationship among the stimuli. Regardless, the key elements must be included (integration) and the critical spatial and temporal relationships must be maintained (synchronization).
The term cue is more troublesome to define, because of its wide variety of uses. Some use the term to mean a stimulus or stimuli which elicit(s) a percept. Others us the term to mean a stimulus or stimuli which elicit(s) a specific action, or provides specific information. However, all of these uses are an attempt to name the critical stimulus elements or patterns that must be included in the simulation. While the precise definitions of the terms are not critical, the sensory and perceptual processes the terms describe are. Human perception is a highly tuned and integrated process that has evolved and developed to respond to specific patterns when certain events occur in the environment. When these relationships are violated, perception is degraded.
The remainder of this paper provides an overview of the integration and synchronization issues in flight simulation. Sources of integration and synchronization errors are identified. Typical effects of these errors on pilot training and performance are discussed. Finally, means available to minimize the errors are reviewed.

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Reference Type: Conference Paper
Author: McMillan, Grant R.; Cardullo, Frank M.
Year: 1999
Title: Integration and synchronization as perceptual issues
Conference Name: The Fifteenth Annual Flight and Ground Vehicle Simulation Update
Conference Location: State University of New York at Binghamton
Date: January 11-15
Author's Title and Affiliation: McMillan: Armstrong Laboratory
Cardullo: State University of New York at Binghamton

Reference Type: Conference Paper
Author: McMillan, Grant R.; Martin, Edward A.; Flach, John M.; Riccio, Gary E.
Year: 1985
Title: Advanced dynamic seats: An alternative to platform motion?
Conference Name: Interservice/Industry Training, Simulation & Education (I/ITSEC) Conference
Conference Location: Orlando, FL
Date: November
Author's Title and Affiliation: McMillan: Armstrong Aerospace Medical Research Laboratory, Wright-Patterson Air Force Base, OH 45433
Martin: Aeronautical Systems Division, Wright-Patterson Air Force Base, OH 45433
Flach: University of Illinois at Urbana-Champaign, Aviation Research Laboratory, IL 61874
Riccio: Systems Research Laboratories, Inc., Dayton, OH 45440
Number of Pages: 11
Keywords: advanced dynamic seats, platform motion, g-seats, RATS, roll-axis training simulator, advanced low cost g-cueing system, ALCOGS
Abstract: The experiment program described in this paper is investigating advanced dynamic seats (g-seats) as an alternative to platform motion systems. The studies have quantified the effects of dynamic seat cueing on the performance of a roll-axis turbulence regulation task, and on transfer of training to a whole-body motion simulator. The studies have clearly demonstrated that the dynamic seat can elicit tracking performance and manual control behavior equivalent to that observed in whole body motion. To date, significant transfer of training from the dynamic seat to whole-body motion has only been observed with pilot subjects. Techniques to achieve the same training benefit with naive trainees are being pursued.

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Reference Type: Conference Proceedings
Author: McQuillan, F.; Ure, R.
Year of Conference: 1992
Title: Use of simulation to prove military worth of advanced platform technologies
Conference Name: AIAA/AHS Flight Simulation Technologies Conference
Conference Location: Hilton Head Island, SC
Publisher: American Institute of Aeronautics and Astronautics (AIAA)
Pages: 79-88
Date: August 24-26
Electronic Resource Number: AIAA-92-4141-CP
Author's Title and Affiliation: CAE Electronics Ltd., St. Laurent, Quebec, Canada
Number of Pages: 10
Keywords: advanced platform technologies, simulation, scenario analysis, database management
Abstract: Spiraling costs in the development and evaluation of new military aircraft are forcing many agencies to look to simulation as a mechanism for advanced platform evaluation.
This paper describes a simulation facility being developed at CAE Electronics Ltd. to support a study of advanced VTOL concepts being conducted by the US army.
The facility allows researchers and engineers to evaluate the effectiveness of aircraft in performing selected missions. It provides a user-definable, high fidelity threat environment with terrain interaction. The experimenter can specify all attributes of the various player and tactical scenario in a flexible and user-friendly manner. A data recording capability is available to log mission results for off-line analysis. For the more promising airframes identified, a real-time piloted simulation is anticipated as the next phase of this project.
Notes: Published in 1992.

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Reference Type: Journal Article
Author: McRuer, D.
Year: 1980
Title: Human dynamics in man-machine systems
Journal: Automatica
Volume: 16
Pages: 237-253
Author's Title and Affiliation: Systems Technology, Inc., 13766 South Hawthorne Boulevard, Hawthorne, CA 90250, USA
Number of Pages: 17
Keywords: adaptive systems, bang-bang control, biocontrol, crossover model, human dynamics, man-machine systems, optimal systems, physiological models, structural isomorphic model
Abstract: The dynamic behavior of human operators in manual control systems has long served as a compelling target for control theory explanations. While many theoretical attempts have been found wanting, some classical and modern control theory concepts have proved useful in practice. In this paper some human dynamic properties are outlined to illustrate the variety of human behavior, and some suitable theoretical treatments are summarized. Time-optimal control theory is used to characterize one form of human behavior. Other behavioral aspects are quantified by the two predominant models in current use--a structurally isomorphic cause-effect model and an algorithmic model utilizing linear-quadratic-gaussian optimal control. Many of the procedures developed to achieve practical utility for these models have parallels useful for automatic control as well.

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Reference Type: Report
Author: McRuer, Duane T.
Year: 1988
Title: Pilot modeling
Series Editor: Advisory Group for Aerospace Research and Development (AGARD)
Series Title: AGARD Lecture Series No. 157: Advances in Flying Qualities
City: Hawthorne, CA
Institution: Systems Technology, Inc.
Pages: 2-1 - 2-30
Report Number: AGARD-LS-157
Author's Title and Affiliation: President, Systems Technology, Inc., 13766 S. Hawthorne Blvd., Hawthorne, CA 90250
Number of Pages: 31
Abstract: This paper begins with a description of pilot control behavior in general. This is followed by emphasizing the essential features of pilot dynamics for closed-loop control of aircraft. The crossover model is presented as the simplest and most useful model for structural-isomorphic form which accounts for some human subsystems as well as the total input-output behavior; and an algorithmic optimal control model which attempts to mimic the pilot's total response only. Both full and divided attention conditions are treated.

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Reference Type: Journal Article
Author: McRuer, Duane T.; Allen, R. Wade; Weir, David H.; Klein, Richard H.
Year: 1977
Title: New results in driver steering control models
Journal: Human Factors
Volume: 19
Issue: 4
Pages: 381-397
Date: August
Author's Title and Affiliation: Systems Technology, Inc., Hawthorne, CA

Abstract: The dynamic control properties of drivers and driver/vehicle systems in steering operations have been widely investigated. This paper presents a short review of the combined compensatory, pursuit, and precognitive features needed to describe the total properties of the driver as a controller. Specific combinations of these features are associated with particular driving maneuvers. Some recent results are presented to confirm previous hypotheses and more completely quantify the models.
The driver-organized system structure for regulation control is reviewed with emphasis on the loops closed and adjustments made by the driver in compensating for vehicle dynamic changes. Pursuit structures are given which describe steering control with preview and as one explanation for lane change maneuvers. Precognitive behavior is then presented as the most skilled mode utilized in rapid lane changes and other well-practiced maneuvers including obstacle avoidance. For all three categories of control, full-scale or simulator data are presented as indications of model verification.

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Reference Type: Journal Article
Author: McRuer, Duane T.; Jex, Henry R.
Year: 1967
Title: A review of quasi-linear pilot models
Journal: IEEE Transactions on Human Factors in Electronics
Volume: 8
Issue: 3
Pages: 231-249
Number of Pages: 19
Abstract: During the past several years, an analytical theory of manual control of vehicles has been in development and has emerged as a useful engineering tool for the explanation of past test results and prediction of new phenomena. An essential feature of this theory is the use of quasi-linear analytical models for the human pilot wherein the models' form and parameters are adapted to the task variables involved in the particular pilot-vehicle situation.
This paper summarizes the current state of these models; experimental data and equations of describing function models for compensatory, pursuit, periodic, and multiloop control situations; the effects of task variables on some of the model parameters; some data on "remnant"; and the relationship of handling qualities ratings to the model parameters.

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Reference Type: Report
Author: McRuer, Duane T.; Krendel, Ezra S.
Year: 1974
Title: Mathematical models of human pilot behavior
City: France
Institution: NATO Advisory Group For Aerospace Research & Development
Date: January
Report Number: AGARDograph No. 188
Author's Title and Affiliation: McRuer: President and Technical Director, Systems Technology, Inc., Hawthorne, CA
Krendel: Professor of Operations Research, University of Pennsylvania, Philadelphia, PA
Number of Pages: 72
Keywords: human pilot behavior, stability, control, display system, flying qualities, quasi-linear models, single-loop system configuration, multi-loop system configuration, Successive Organization of Perception (SOP) theory
Abstract: The use of mathematical models of the human pilot in analyses of the pilot/vehicle system has brought a new dimension to the engineering treatment of flying qualities, stability and control, pilot/vehicle integration, and display system considerations. As an introduction to such models, elementary concepts and specific examples are used to set the stage for a step-by-step development of what is known about the human pilot as a dynamic control component. In the process, quasi-linear models for single-loop systems with visual stimuli and multiloop systems with visual stimuli are presented and then extended to

cover multiloop, multi-modality situations. Empirical connections between the pilot dynamics and pilot ratings are also considered.
Some of the most important nonlinear features of human pilot behavior in adapting to changes in the character of the stimuli are described and tied to the quasi-linear models via the Successive Organization of Perception (SOP) theory, which is reviewed and elaborated. Dual-mode control models needed to describe the pilot's behavior in response to sudden transients are presented, along with pursuit and compensatory elements of the SOP continuum.
The current status of mathematical pilot models is shown to cover random, random-appearing, and transient inputs for single- and multi-loop system configurations. An extensive bibliography of applications and a summary of analysis problems which have been addressed is included, as is a short general status summary and critique of existing models in the form of a listing of shortcomings and problem areas.

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Reference Type: Magazine Article
Author: Mecham, Michael
Year: 1994
Title: Cathay refines approach to simulator training
Magazine: Aviation Week & Space Technology
Pages: 35, 37
Date: January 17
Number of Pages: 2

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Reference Type: Magazine Article
Author: Mecham, Michael
Year: 1994
Title: MD-11 introduction prompts JAL maintenance review
Magazine: Aviation Week & Space Technology
Pages: 36-37
Date: January 24
Number of Pages: 2

*****

Reference Type: Electronic Article
Author: Mechtronix Systems Inc. (MSI)
Year: 2006
Title: Air Deccan to take delivery of an Ascent ATR 42/72 Full Flight Trainer from Aerosim-Mechtronix
Periodical Title: Asia Pacific Airline Training Symposium (APATS)
Author's Title and Affiliation: Mechtronix, Montreal
Number of Pages: 2
Keywords: ATR 42-500, ATR 72-500, turboprop, FFT, Air Deccan, Mechtronix
Abstract: The Avions de Transport Regional (ATR) Training Centre has purchased an Ascent Full Flight Trainer (FFT) for the ATR 42/72 family of aircraft for use by Air Deccan. The FFT will be easily re-configurable between the following configurations: ATR 42-300, ATR 42-500, ATR 72-200, ATR 72-500.
URL: http://www.mechtronix.com/c/mech/file_db/News_Pdf_e/022106air_deccan_atr_4272_fft_en.pdf
Access Date: February 21

*****

Reference Type: Electronic Article
Author: Mechtronix Systems Inc. (MSI)
Year: 2006
Title: ATR Training Center gets dual certification for its first Mechtronix Ascent ATR 42-300 Full Flight Trainer
Author's Title and Affiliation: Mechtronix, Montreal, Canada
Number of Pages: 2
Keywords: ATR 42-500, ATR 72-500, turboprop, Mechtronix, Full Flight Trainer (FFT)
Abstract: Mechtronix's ATR 42/72 Ascent Full Flight Trainer (FFT) has received the dual qualification of FNPT II MCC and FTD Level 2 under JAR-STD 3A and 2A, respectively, on December 15, 2005 at Toulouse based ATR Training Center (ATC). JAR-STD 2A Level 2 is the highest level FTD qualification under JAA and corresponds to FAA Level 6 FTD.
URL: http://www.mechtronix.com/c/mech/file_db/News_Pdf_e/DoubleCertificationen.pdf
Access Date: January 25

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Reference Type: Electronic Article
Author: Mechtronix Systems Inc. (MSI)
Year: 2006
Title: Skyblue Aviation orders ATR 42/72 Ascent Full Flight Trainer from Mechtronix
Author's Title and Affiliation: Mechtronix, Montreal, Canada
Skyblue Aviation, UK
Number of Pages: 2
Keywords: ATR 42, ATR 72, turboprop, Full Flight Trainer (FFT), Skyblue Aviation, Mechtronix
Abstract: UK TRTO cites simulator's quality performance, low purchase price and affordable operating costs as key factors in selection of Mechtronix Systems, a fast growing worldwide provider of flight training equipment.
URL:
http://www.mechtronix.com/c/mech/file_db/News_Pdf_e/SKYBLUEAVIATION_press_release_010806_XHjv.pdf
Access Date: August 2, 2006

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Reference Type: Electronic Article
Author: Mechtronix Systems Inc. (MSI); ATR Training Center
Year: 2004
Title: Aerosim-Mechtronix integrated training architecture in motion at ATR
Author's Title and Affiliation: Mechtronix, Montreal, Canada
ATR, Toulouse, France
Number of Pages: 2
Keywords: ATR 42, ATR 72, turboprop, Full Flight Trainer (FFT), ATR, Mechtronix
Abstract: After an extensive evaluation process, ATR has recently selected Aerosim-Mechtronix / Claris team to supply a complete family of training tools for the ATR 42/72. The order includes: an Ascent Full Flight Trainer, an Aerosim Virtual Flight Deck, and two Aerosim Virtual Procedure Trainers to be based at the ATR Training Center (ATC) in Toulouse, France.
URL: http://www.mechtronix.com/c/mech/file_db/News_Pdf_e/ATR_Announcement_151204_ATR.pdf
Access Date: December 15

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Reference Type: Report
Author: Meiry, Jacob L.
Year: 1966
Title: The vestibular system and human dynamic space orientation

Institution: Massachusetts Institute of Technology (MIT)
Date: October
Report Number: NASA CR-628
Author's Title and Affiliation: Massacusetts Institute of Technology (MIT)
Recipient's Title and Affiliation: National Aeronautics and Space Administration (NASA)
Number of Pages: 206
Abstract: The motion sensors of the vestibular system are studied to determine their role in human dynamic space orientation and manual vehicle control. The investigation yielded control models for the sensors, descriptions of the subsystems for eye stabilization, and demonstrations of the effects of motion cues on closed loop manual control.
Experiments on the abilities of subjects to perceive a variety of linear motions provided data on the dynamic characteristics of the otoliths, the linear motion sensors. Angular acceleration threshold measurements supplemented knowledge of the semicircular canals, the angular motion sensors. Mathematical models are presented to describe the known control characteristics of the vestibular sensors, relating subjective perception of motion to objective motion of a vehicle.
The vestibular system, the neck rotation proprioceptors and the visual system form part of the control system which maintains the eye stationary relative to a target or a reference. The contribution of each of these systems was identified through experiments involving head and body rotations about a vertical axis. Compensatory eye movements in response to neck rotation were demonstrated and their dynamic characteristics described by a lag-lead model. The eye motions attributable to neck rotations and vestibular stimulation obey superposition when both systems are active.
Human operator compensatory tracking is investigated in simple vehicle orientation control systems with stable and unstable controlled elements. Control of vehicle orientation to a reference is simulated in three models: visual, motion and combined. Motion cues sensed by the vestibular system and through tactile sensation enable the operator to generate more lead compensation than in fixed base simulation with only visual input. The tracking performance of the human in an unstable control system near the limits of controllability is shown to depend heavily upon the rate information provided by the vestibular sensors.

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Reference Type: Journal Article
Author: Merfeld, Daniel M.; Young, Laurence R.; Oman, Charles M.; Shelhamer, Mark J.
Year: 1993
Title: A multidimensional model of the effect of gravity on the spatial orientation of the monkey
Journal: Journal of Vestibular Research
Volume: 3
Pages: 141-161
Author's Title and Affiliation: Merfeld, Young, Oman: Massachusetts Institute of Technology, Man-Vehicle Laboratory, Cambridge, MA
Shelhamer: Johns Hopkins University, School of Medicine, Baltimore, MD
Number of Pages: 21
Keywords: spatial orientation, upset recovery training (URT)
Abstract: A "sensory conflict" model of spatial orientation was developed. This mathematical model was based on concepts derived from observer theory, optimal observer theory, and the mathematical properties of coordinate rotations. The primary hypothesis is that the central nervous system of the squirrel monkey incorporates information about body dynamics and sensory dynamics to develop an internal model. The output of this central model (expected sensory afference) is compared to the actual sensory afference, with the difference defined as "sensory conflict." The sensory conflict information is, in turn, used to drive central estimates of angular velocity ("velocity storage"), gravity ("gravity storage"), and linear acceleration ("acceleration storage"), toward more accurate values. The model successfully predicts "velocity storage" during rotation about an earth-vertical axis. The model also successfully predicts that the time constant of the horizontal vestibulo-ocular reflex is reduced and that the axis of eye rotation shifts toward alignment with gravity following postrotatory tilt. Finally, the model predicts the bias, modulation, and decay components that have been observed during off-vertical axis rotations (OVAR).

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Reference Type: Book Section
Author: Merfeld, D. M.; Zupan, L. H.
Year: 2003
Title: Influence of rotational cues on the neural processing of gravito-inertial force
Editor: Harris, Laurence; Jenkin, Michael
Book Title: Levels of Perception
Pages: 1-40
Author's Title and Affiliation: Department of Otology and Laryngology, Harvard Medical School
Jenks Vestibular Physiology Laboratory, Massachusetts Eye and Ear Infirmary
Number of Pages: 41
Abstract: Sensory systems often provide ambiguous information. For example, otolith organs measure gravito-inertial force (GIF), the sum of gravitational force and inertial force due to linear acceleration. According to Einstein's equivalence principle, no set of linear accelerometers alone can distinguish gravitational force (which changes with head orientation during head tilt) from inertial force (which changes with linear acceleration of the head). Therefore, the central nervous system (CNS) must use other sensory cues to distinguish tilt from translation. For example, the CNS can use rotational cues provided by the semicircular canals and vision. Much of this chapter provides a brief review of studies showing the influence of rotational cues on the neural processing of tilt and translation. However, we also include previously unpublished data. We begin by discussing the underlying physics (and associated neural processes) and neural representations. We then present studies that measure the influence of rotational cues on tilt responses before presenting studies of translation responses. We finish by reviewing modeling approaches to sensory integration for both tilt and translation responses.
Notes: On July 6, 2007, the web page was no longer accessible.
URL: http://paperairplane.mit.edu/16.423J/Space/SBE/neurovestibular/NVChapter.doc

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Reference Type: Report
Author: Merriken, Michael S.; Johnson, William V.; Cress, Jeffrey D.; Riccio, Gary E.
Year: 1988
Title: Time delay communication using supplementary cues in aircraft simulator systems
Institution: American Institute of Aeronautics and Astronautics (AIAA)
Type: Experimental Report
Electronic Resource Number: AIAA 88-4626-CP
Number of Pages: 9
Abstract: This study investigated the effects of providing real-world supplementary information to the visual and tactual modalities to reduce the deleterious effects of a delayed primary display on operator control performance. The supplementary visual and motion cues were presented at two different rates: (1) at the same rate as the primary display and (2) at a rate 133 ms faster. The results indicate that the conditions with the faster updating secondary cues had better performance in altitude control than the conditions with the cues at the same rate as the delayed primary display. There were no significant effects for heading control. When compared to a control condition with no supplementary cue there were no statistical differences but the trend of the faster updating secondary cue conditions having better performance scores was maintained for both altitude and heading control.

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Reference Type: Thesis
Author: Mesland, Barbara
Year: 1998
Title: About horizontal self-motion perception...
City: Utrecht, The Netherlands
University: Utrecht University
Thesis Type: Ph.D. Thesis
Keywords: self-motion, human perception, visual illusion

Abstract: This thesis discusses the technique for measuring perceived horizontal self-motion indirectly, using perceived object-motion. It also describes sensory interactions during the horizontal linear self-motion perception.

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Reference Type: Report
Author: Mesland, B. S.; Bles, W.; Wertheim, A. H.; Groen, E. L.
Year: 1998
Title: The influence of expectation on the perception of linear horizontal motion
City: Soesterberg, The Netherlands
Institution: TNO Human Factors Research Institute
Date: March 23
Type: TNO report
Report Number: TM-98-A010
Number of Pages: 23
Keywords: motion study, perception of movement, vestibular responses
Abstract: In normal situations the judgment of linear horizontal self-motion largely depends on visual information. In the absence of adequate visual feedback, however, the information provided the otolith organs and non-vestibular proprioceptors (together called linear proprioceptive sensors) becomes more important. The particular thing about these sensors is that they respond to linear acceleration, which may arise from translatory motion as well as from the gravitational acceleration. As a consequence it is difficult for these sensors to differentiate between linear translations and tilt with respect to gravity. This ambiguity may lead to the false percept of tilt during pure linear accelerations along a horizontal path. Still, it was our experience that these illusory percepts only seldomly occur when we oscillate subjects to and fro on a linear track (the ESA-sled). It was hypothesized that prior knowledge of subjects, who had seen the linear motion device before the experiment, may have biased the percept toward a vertical sensation of linear self-motion as opposed to an illusory sensation of self-tilt. In other words, their expectation may have influenced their perception of the stimulus. Therefore, two experiments were carried out in which this cognitive factor was controlled as an independent variable. In the first experiment, blindfolded subjects who were completely naive regarding the characteristics of the motion device were exposed to oscillatory linear motion at frequencies of 0.159 and 0.252 Hz. In the second experiment similar linear motion was applied, but this time in combination with various angles of actual tilt of the subject's seat. The subjects in this experiment were informed beforehand that they would be exposed to various combinations of linear motion and tilt, so that they--although not completely naive--could not have any expectation about whether to perceive tilt or translation. In both experiments the dependent variable was the report about experienced self-motion and self-tilt. The results of both experiments unambiguously confirm that illusory self-tilt is sensed much more frequently when the subject has no precise expectation about the linear motion. Expressed in another way, the expectation of subjects who have seen the sled beforehand seems to enhance the threshold for perceiving self-tilt. It is concluded that expectation from prior knowledge and previous experience should be taken into account when modeling the perception of self-motion.
The experiments described in this report clearly demonstrate that the expectation, or mental state, of a subject has significant bearing on the judgment of linear horizontal self-motion. Clearly, the interpretation of sensory information about self-motion depends more on the transfer characteristics of the peripheral senses alone. As a consequence, one has to take cognitive factors, such as prior knowledge or previous experience, into account when investigating or modeling the perception of self-motion. From this point of view it will be more difficult to exactly predict or reconstruct the sensations of an aviator on the basis of the physical characteristics of a flight path. Seen from the positive side, the expectation of an experienced pilot is likely to be advantageous for the appreciation of simulated motion in a flight simulator.

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Reference Type: Magazine Article
Author: Mikula, J.
Year: 2004
Title: Modeling and simulation
Magazine: Aerospace America
Volume: 12
Pages: 80
Date: December
Number of Pages: 1

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Reference Type: Conference Paper
Author: Mikula, Julie; Chung, William W. Y.; Tran, Duc
Year: 1999
Title: Motion fidelity criteria for roll-lateral translational tasks
Conference Name: AIAA Modeling and Simulation Technologies Conference and Exhibit
Conference Location: Portland, OR
Publisher: American Institute of Aeronautics and Astronautics (AIAA)
Date: August 9-11
Electronic Resource Number: AIAA 99-4329
Author's Title and Affiliation: Mikula: NASA Ames Research Center, Moffett Field, CA
Chung: Logicon Information Systems and Services, Moffett Field, CA
Tran: NASA Ames Research Center, Moffett Field, CA
Number of Pages: 11
Abstract: A systematic effort investigating the motion cueing dependencies for coordinated roll-lateral tasks was designed for this study. Previous studies suggested a possible criterion to determine required motion fidelity. This experiment was expanded to confirm the previously suggested criteria by investigating a full range of rotational and translational motion attenuation and phase distortion. Two translational tasks were developed: (1) a helicopter making a 20-ft translation in hover, and (2) a fixed-wing jet making a 20-ft translation at a cruising speed of 250 knots. Both aircraft had desired handling qualities. Motion fidelity ratings and handlings qualities ratings were collected as the subjective data. The results were consistent with and extended the previously suggested fidelity criteria for coordinated roll-lateral tasks.
URL: http://www.ffc.arc.nasa.gov/library_docs/tech_papers/AIAA%201999/Mikula/1999_4329.pdf

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Reference Type: Conference Proceedings
Author: Miller, David G.; Kocher, Erik; Hughes, Duncan F.; Grugan, Richard A.; Taylor, James E.; Bender, Jeffrey S.
Year of Conference: 2009
Title: Complementary moving base and dynamic motion seat cueing for rotorcraft simulation
Conference Name: AIAA Modeling and Simulation Technologies Guidance, Navigation, and Control Conference
Conference Location: Chicago, IL
Publisher: American Institute of Aeronautics and Astronautics (AIAA)
Pages: 1-25
Date: Aug. 10-13
Electronic Resource Number: AIAA 2009-6249
Author's Title and Affiliation: Miller: Technical Fellow, Boeing Rotorcraft Systems, Philadelphia, PA
Kocher: Test Pilot, Boeing Rotorcraft Systems, Philadelphia, PA
Hughes: Project Engineer, Boeing Rotorcraft Systems, Philadelphia, PA
Grugan: Project Engineer, Boeing Rotorcraft Systems, Philadelphia, PA
Taylor: Simulation Analyst, Boeing Rotorcraft Systems, Philadelphia, PA
Bender: Test Pilot, McDonnell Douglas Helicopter Systems, Mesa, AZ

Number of Pages: 25
Keywords: hexapod moving base, dynamic motion seat
Abstract: A complementary moving base and dynamic motion seat cueing system for a rotorcraft engineering development simulator is described. A 3 degree of freedom dynamic motion seat is installed within a simulator cab mounted on a six degree of freedom hexapod moving base to provide complementary low and high frequency motion cues. The moving simulator cab and dynamic motion seat operate within a dome on which Computer Generated Imagery (CGI) of the outside world is projected. A blade element rotor model is used to generate a full spectrum of dynamic zero harmonic and vibratory motion cues using physics based assumptions and empirical scaling relationships that can be applied generically to current and future rotorcraft designs. Complementary filtering techniques used to synergize the dynamic seat and moving base motion cues are described. Evaluation of the complementary motion base/seat cueing system by several experienced test pilots at Boeing Rotorcraft Systems Philadelphia Site Flight Simulation Laboratory is discussed. Performance of fixed base, motion base only, motion seat only, and complementary motion base/seat cueing configurations are compared. The complementary motion base/seat cueing system improves simulator motion fidelity ratings and provides closer correlation between handling qualities ratings obtained in flight test and piloted simulation for ADS-33E-PRF Mission Task Elements conducted with a Chinook helicopter.

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Reference Type: Journal Article
Author: Miller, Earl F.; Fregly, Alfred F.; Graybiel, Ashton
Year: 1968
Title: Visual horizontal-perception in relation to otolith-function
Journal: American Journal of Psychology
Volume: 81
Issue: 4
Pages: 488-496
ISSN: 0002-9556
Electronic Resource Number: 10.2307/1420810
Number of Pages: 9
Accession Number: 1969-09297-001
Keywords: otolith-function, visual horizontal-perception relationship, normal & deat Ss
Abstract: To determine the influence of the otolith-organs on visually perceived direction of space, the constant and variable errors of 15 normal persons and of 10 deaf persons with bilateral labyrinthine defects (LDs) were compared for 19 positions of body-tilt within 90° of gravitational vertical. The general perceptual pattern was similar for the 2 groups, although that of the labyrinthine-defective group was more variable and revealed greater E and A effects in several of the tilt-positions. The significantly larger E effect occurred even though these LD Ss manifested little or no ocular counterroll. (17 ref.) (PsycINFO Database Record (c) 2009 APA, all rights reserved)

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Reference Type: Journal Article
Author: Miller, Earl F.; Graybiel, A.
Year: 1975
Title: Thresholds for the perception of angular acceleration as indicated by the oculogyral illusion
Journal: Perception & Psychophysics
Volume: 17
Issue: 3
Pages: 329-332
ISSN: 0031-5117 (Print)
1532-5962 (Electronic)
Number of Pages: 4
Accession Number: 1975-22282-001

Keywords: oculogyral illusion, perception thresholds of angular acceleration, US Navy pilots & enlisted men & civilians
Abstract: The oculogyral illusion may be perceived by a person passively exposed to angular acceleration as apparent motion (in the direction of turn) of visual objects that are fixed relative to him. The illusion has its genesis in the semicircular canals and a knowledge of cupuloendolymph mechanisms, the role of adaptation effects and the influence of secondary etiological factors are all essential for predicting its behavior under different stimulus conditions. Studies have shown that its perception under ideal test conditions yields lower threshold values than other canal response indicators: the manifestation of nystagmus, and the sensation and aftersensation of rotation. The thresholds of the illusion are so low that their measurement is limited by the precision of the rotating device. A highly sophisticated servo-controlled device, the Rotating Litter Chair (RLC), was developed expressly for determining with this indicator any changes in cupular thresholds of response that might occur during the prolonged weightless Skylab missions. The purpose of the report is to evaluate the RLC and a relatively short method for determining the thresholds of perception of the illusion in a large sample of normal subjects and in four deaf persons with severe bilateral labyrinthine defects.

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Reference Type: Journal Article
Author: Miller, Earl F. II; Graybiel, Ashton
Year: 1966
Title: Magnitude of gravitoinertial force, an independent variable in egocentric visual localization of the horizontal
Journal: Journal of Experimental Psychology
Volume: 71
Issue: 3
Pages: 452-460
Author's Title and Affiliation: Research Department, United States Naval Aviation Medical Center
Number of Pages: 9
Keywords: visual perception, horizontal localization, gravitoinertial magnitude force, vestibular sense, gravitoinertial force & visual localization of horizontal, vision, color, visual optics, motion detection
Abstract: The direction of gravitoinertial force (GIF), i.e., the resultant of the gravitational and induced centripetal force vectors, was held constant while the magnitude of force was varied from 1.0 to 2.0 G to determine its effects upon egocentric visual localization (EVL) of the horizontal. 8 normal and 2 labyrinthine-defective (L-D) men served as Ss. The EVL of the horizontal was found to deviate from the gravitoinertial horizontal as a function of magnitude of the GIF. This magnitude effect tended to increase with the amount of body tilt from its alignment with the resultant force. The increase of GIF in the case of L-D Ss resulted generally in an apparent rotation of the physical horizontal in a direction of the E then A phenomenon in contrast to the normal Ss who manifested ever increasing amounts of the E phenomenon only. Based upon these findings and the assumption that Ss differed under the experimental conditions primarily in otolithic function, the possible roles of otolithic and nonotolithic gravireceptor cues in visual localization in the absence of empirical visual cues are discussed.

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Reference Type: Conference Paper
Author: Miller, G. Kimball, Jr.; Riley, Donald R.
Year: 1976
Title: The effect of visual-motion time delays on pilot performance in a pursuit tracking task
Conference Name: AIAA Visual and Motion Simulation Conference
Conference Location: Dayton, OH
Publisher: American Institute of Aeronautics and Astronautics (AIAA)
Date: April 26-28
Author's Title and Affiliation: AIAA Members, NASA Langley Research Center, Hampton, VA 23665
Number of Pages: 3

Abstract: A study has been made to determine the effect of visual-motion time delays on pilot performance of a simulated pursuit tracking task. Three interrelated major effects have been identified: task difficulty, motion cues, and time delays. As task difficulty, as determined by airplane handling qualities or target frequency, increases, the amount of acceptable time delay decreases. However, when relatively complete motion cues are included in the simulation, the pilot can maintain his performance for considerable longer time delays. In addition, the number of degrees of freedom of motion employed is a significant factor.
URL: full report: http://ntrs.nasa.gov/archive/nasa/casi.ntrs.nasa.gov/19770013136_1977013136.pdf

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Reference Type: Report
Author: Miller, G. Kimball Jr.; Riley, Donald R.
Year: 1977
Title: The effect of visual-motion time delays on pilot performance in a simulated pursuit tracking task
City: Hampton, VA
Institution: National Aeronautics and Space Administration (NASA)
Date: March
Type: Technical Note
Report Number: NASA TN D-8364
Number of Pages: 97
Abstract: An experimental study has been made to determine the effect on pilot performance of time delays in the visual and motion feedback loops of a simulated pursuit tracking task. Three major interrelated factors were identified: task difficulty in the form of airplane handling qualities or target frequency, the amount and type of motion cues, and time delay itself. In general, the greater the task difficulty, the smaller the time delay that could exist without degrading pilot performance. Conversely, the greater the motion fidelity, the greater the time delay that could be tolerated. The effect of motion was, however, pilot dependent.

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Reference Type: Report
Author: Miller, James C.; Sharkey, Thomas J.; Graham, Glenna A.; McCauley, Michael E.
Year: 1993
Title: Autonomic physiological data associated with simulator discomfort
City: Moffett Field, CA
Institution: National Aeronautics and Space Administration (NASA), Ames Research Center
Date: February
Report Number: CONTRACT NAS2-12927
NASA_CR-177609
Author's Title and Affiliation: Monterey Technologies, Inc., P.O. Box 223699, Carmel, CA 93922
Number of Pages: 30
Keywords: simulator discomfort, simulation, helicopter, virtual reality, motion sickness, simulator sickness, heart period, heart rate, electrocardiogram, electrogastrogram
Abstract: We report here the development of a physiological monitoring capability for the Army's advanced helicopter simulator facility and some preliminary physiological data. Our objective was to demonstrate sensitivity of physiological measures in this simulator to self-reported simulator sickness. The data suggested that heart period, hypergastria, and skin conductance levels were more sensitive than were vagal tone and normal electrogastric activity.

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Reference Type: Conference Proceedings
Author: Mohler, Betty J.; Thompson, William B.; Riecke, Bernhard; Bülthoff, Heinrich H.
Year of Conference: 2005
Title: Measuring vection in a large screen virtual environment

Conference Name: 2nd Symposium on Applied Perception in Graphics and Visualization (APGV'05),
Publisher: ACM Press
Pages: 103 - 109
Author's Title and Affiliation: Mohler and Thompson: University of Utah, Salt Lake City, Utah
Riecke and Bülthoff: Max Plank Institute for Biological Cybernetics, Tübingen, Germany
Keywords: virtual environments, locomotion, self-motion perception, vection
Abstract: This paper describes the use of a large screen virtual environment to induce the perception of translational and rotational self-motion. We explore two aspects of this problem. Our first study investigates how the level of visual immersion (seeing a reference frame) affects subjective measures of vection. For visual patterns consistent with translation, self-reported subjective measures of self-motion were increased when the floor and ceiling were visible outside of the projection area. When the visual patterns indicated rotation, the strength of the subjective experience of circular vection was unaffected by whether or not the floor and ceiling were visible. We also found that circular vection induced by the large screen display was reported subjectively more compelling than translational vection. The second study we present describes a novel way in which to measure the effects of displays intended to produce a sense of vection. It is known that people unintentionally drift forward if asked to run in place while blindfolded and that adaptations involving perceived linear self-motion can change the rate of drift. We showed for the first time that there is a lateral drift following perceived rotational self-motion and we added to the empirical data associated with the drift effect for translational self-motion by exploring the condition in which the only self-motion cues are visual.
URL: http://www.kyb.mpg.de/publications/attachments/mohler-etal-apgv-2005_3489[0].pdf

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Reference Type: Journal Article
Author: Molloy, Robert; Parasuraman, Raja
Year: 1996
Title: Monitoring an automated system for a single failure: Vigilance and task complexity effects
Journal: Human Factors
Volume: 38
Issue: 2
Pages: 311-322
Date: June
Number of Pages: 12
Abstract: The present study examined the effects of task complexity and time on task on the monitoring of a single automation failure during performance of a complex flight simulation task involving tracking, fuel management, and engine-status monitoring. Two groups of participants performed either all three flight simulation tasks simultaneously (multi-complex task) or the monitoring task alone (single-complex task); a third group performed a simple visual vigilance task (simple task). For the multi-complex task, monitoring for a single failure of automation control was poorer than when participants monitored engine malfunctions under manual control. Furthermore, more participants detected the automation failure in the first 10 min of a 30 min session than in the last 10 min of the session, for both the simple and the multi-complex task. Participants in the single-complex condition detected the automation failure equally well in both periods. The results support previous findings of inefficiency in monitoring automation and show that automation-related monitoring inefficiency occurs even when there is a single automation failure. Implications for theories of vigilance and automation design are discussed.

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Reference Type: Conference Paper
Author: Monfort, M.
Year: 1970
Title: Engineering analysis
Conference Name: Simulation; Flight Mechanics Panel
Conference Location: Ames Research Center, Moffett Field, CA
Publisher: Advisory Group for Aerospace Research and Development (AGARD)

Date: March
Number of Pages: 21
Keywords: aircraft simulation, pilot workload, pilot rating
Notes: Lead discussion by D. R. Madill, W. R. Reynolds, I. L. Ashkenas and D. T. McRuer. Also includes an open discussion.

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Reference Type: Conference Paper
Author: Mooij, H. A.
Year: 1987
Title: Technology involved in the simulation of motion cues: The current trend
Conference Name: Aerospace Medical Panel Symposium on Motion Cues in Flight Simulation and Simulator Induced Sickness
Conference Location: Brussels, Belgium
Publisher: Advisory Group for Aerospace Research and Development (AGARD)
Date: September 29
Author's Title and Affiliation: National Aerospace Laboratory NLR, Amsterdam, The Netherlands
Number of Pages: 15
Keywords: motion cues, simulator sickness, visual display, motion cue generation, current trend in visual and motion systems, basic cueing methodology in flight simulation, developments in image generation, image display, platform motion cue generation and motion hardware mechanisms, importance of maintenance and calibration of flight simulator installations
Abstract: The subject of motion cue generation is a topic that requires serious attention from all involved in the design, development and manufacture of flight simulators. The enhanced realism in the depiction of terrain, sky, and other aircraft available in current visual systems has been associated with an increasing number of instances of simulator sickness. This form of sickness is the constellation of symptoms which may be experienced by pilots as a result of flying a simulator.
As one of the introductory papers of the AGARD Aerospace Medical Panel Symposium on "Motion Cues in Flight Simulation and Simulator Induced Sickness," this paper presents observations concerning the current trend in visual and motion systems.
After an introduction of basic cueing methodology in flight simulation, the overview concentrates on developments in image generation, image display platform motion cue generation and motion hardware mechanisms. The paper concludes with some observations concerning the importance of maintenance and calibration of flight simulator installations.
URL: http://stinet.dtic.mil/oai/oai?verb=getRecord&metadataPrefix=html&identifier=ADA202492

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Reference Type: Conference Paper
Author: Moon, Richard N.
Year: 1985
Title: Providing high performance visual simulation at low cost
Conference Name: Interservice/Industry Training, Simulation & Education (I/ITSEC) Conference
Conference Location: Orlando, FL
Date: November
Author's Title and Affiliation: Evans & Sutherland Computer Corporation, 580 Arapeen Drive, Salt Lake City, UT 84108
Number of Pages: 6
Abstract: For years, the users of visual systems, in both the military and commercial worlds, have made a plea to the developers to significantly lower the costs of those visual systems. Then, in a second breath, they have continued to demand high visual fidelity. Not surprisingly, the trend among visual system developers has been to provide more capabilities for higher cost. This paper describes a system design where a serious and concerted effort has been made to lower costs, while still maintaining the features most essential and effective for training tasks. During the highly selective process of determining system features, some capabilities, such as smooth shading, color blending and transparencies, were seriously

questioned. Other capabilities, such as texture, scene detail management, resolution, dynamic coordinate systems, and reasonable image quality, remain high on the list. The paper describes how the essential features were incorporated in a highly cost-effective design with surprising flexibility and modularity. Painstaking efforts were made to optimize the hardware efficiency, making use of custom, semicustom, and commercial VLSI. These latest technologies have made possible a parallel processor architecture in the geometric processor--a departure from capabilities ranging from low-cost, night-only operation to high-resolution, daylight scenes rivaling the current high-end systems. All of this can be contained in a single card cage per channel. The challenge of the visual users has been met.

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Reference Type: Web Page
Author: Moorabbin Flying Services (MFS)
Title: Motion platforms
Access Year: 2007
Access Date: August 15
Author's Title and Affiliation: "Moorabbin Airport's premiere pilot training facility" (Australia)
URL:
http://www.mfs.com.au/MFS_Motion_Platforms.htm#Three%20Rotational%20Degrees%20of%20Freedom

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Reference Type: Journal Article
Author: Morgan, P.L.
Year: 2003
Title: Null hypothesis significance testing: Philosophical and practical considerations of a statistical controversy
Journal: Exceptionality
Volume: 11
Issue: 4
Pages: 209-221
Keywords: null hypothesis
Abstract: This article outlines underlying logic of null hypothesis testing and the philosophical and practical problems associated with using it to evaluate special education research.

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Reference Type: Book Section
Author: Morimoto, M.; Ando, Y.
Year: 1982
Title: On the simulation of sound localization
Editor: Gatehouse, R. W.
Book Title: Localization of Sound: Theory and Applications
City: Groton, CT
Publisher: Amphora Press
Pages: 85-97
Author's Title and Affiliation: Faculty of Engineering, Kobe University, Nada, Kobe 657, Japan
Number of Pages: 13

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Reference Type: Journal Article
Author: Morland, A. B.; Bronstein, A. M.; Ruddock, K. H.; Wooding, D. S.
Year: 1998
Title: Oscillopsia: Visual function during motion in the absence of vestibulo-ocular reflex

Journal: Journal of Neurology & Psychiatry
Volume: 65
Issue: 6
Pages: 828-835
Electronic Resource Number: 10.1136/jnnp.65.6.828
Number of Pages: 8
Accession Number: 1998-03024-001
Keywords: loss of vestibulo-ocular reflex, visual function & eye movements & temporal & spatial vision during motion, labyrinthine defective 31-63 yr olds with oscillopsia
Abstract: Studied the effects of loss of vestibular function on spatiotemporal vision and the mechanisms that enable labyrinthine defective (LBD) patients to adapt to oscillopsia. Visual function and eye movements were assessed in 7 normal Ss and in 4 LBD patients with oscillopsia due to absent vestibulo-ocular reflex. Normal and LBD Ss exhibited similar temporal responses while static and under body oscillation. Also, the 2 groups achieved similar results in spatial responses under static conditions, but body oscillation reduced threshold sensitivities and shifted the spatial response function toward lower spatial frequencies in LBD Ss only. Similar changes in spatial responses were seen during oscillation of the visual stimulus in both groups. Two LBD Ss achieved normal velocity discrimination, but the other 2 showed abnormal responses to visual stimulus movement.

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Reference Type: Report
Author: Morrison, John
Year: 1990
Title: Power analysis of gunnery performance measures: Differences between means of two independent groups
Institution: Human Resources Research Organization
Date: January
Report Number: Technical Report 871
Number of Pages: 25

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Reference Type: Conference Paper
Author: Morrow, D. ; Prinzo, V.O.
Title: Improving pilot/ATC voice communication in general aviation
Keywords: communication, pilot, ATC, message length, message format
Abstract: This paper examines two variables that may affect pilot/ATC communication, message length and format of numeric information. The investigators found that message length does impact communication, and that the effect of the format of the information does not (the very limited evidence for a potential advantage of the grouped format on page 19 is, at best, weak). The effect of message length has been amply demonstrated in both laboratory studies and examinations of audiotapes recorded in the operational environment. The lack of an effect of numerical format in a General Aviation environment and during a realistic flight scenario provides a useful confirmation of results that were found in previous laboratory experiments with airline pilots under more controlled conditions (namely, by eliminating pilot expectations).

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Reference Type: Research Proposal
Author: Mulder, Max
Year: 2005
Title: A cybernetic Approach to Assess Simulator Fidelity
Publisher: NWO Vidi
Author's Title and Affiliation: Kluyverwig 1, 2629 HS Delft
Keywords: Cybernetics, vehicle simulation fidelity, modelling human perception and performance, visual and vestibular motion perception, system identification
URL: http://www.tudelft.nl/live/binaries/bd017e68-61bc-4c4f-a2b8-7ae4921b8ba5/doc/MMVidi_inet.pdf

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Reference Type: Report
Author: Muller, R. C.; Allgood, C. O.; Van Hoy, B.
Year: 1988
Title: Prototype data acquisition and analysis system for navy operational flight simulators
Report Number: DE88 014557
Author's Title and Affiliation: Oak Ridge National Laboratory, Oak Ridge, TN
Number of Pages: 5
Keywords: flight simulators, hardware, operating systems
Abstract: A problem of flight simulators has been the discomfort experienced by some pilots to the point of nausea. Likely explanations are a significant lack of synchronization between sight and movement as well as motion in the critical frequency magnitude region. A program to examine this problem has been undertaken at Oak Ridge National Laboratory, and the selection of appropriate computer hardware and software for analyzing motion and visual systems in real time is described. While requirements such as huge data acquisition rate and high rates operations have driven the selections, rapid advances in computer technologies guided system development toward easy upgrade at modest cost. Results for use and demonstration have been positive, especially in the areas of reliability and ease of use.

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Reference Type: Conference Paper
Author: Murray, P. M.; Barber, B.
Year: 1985
Title: Visual display research tool
Conference Name: Flight Mechanics Panel Symposium on Flight Simulation
Conference Location: Cambridge, United Kingdom
Publisher: Advisory Group for Aerospace Research and Development (AGARD)
Date: September 30-October 3
Author's Title and Affiliation: Rediffusion Simulation Ltd, Gatwick Road, Crawley, W.Sussex RH10 2RL, United Kingdom
Number of Pages: 8
Keywords: visual display research tool, helmet mounted
Abstract: The simulation of the field of view seen by the pilot through the cockpit canopy where high detail over a wide field is required, as in low-level flight, navigation and target acquisition for example, remains a difficult and expensive problem. The Visual Display Research Tool (VDRT) is a new concept in visual displays which utilizes this 'area of interest' approach by matching its display parameters to those of the human eye.
Notes: Published in September 1986.

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Reference Type: Journal Article
Author: Muth, Eric R.
Year: 2009
Title: The challenge of uncoupled motion: duration of cognitive and physiological aftereffects
Journal: Human Factors
Volume: 51
Issue: 5
Pages: 752-761
Date: October 2009
Author's Title and Affiliation: Associate Professor of Psychology at Clemson University
Number of Pages: 10
Abstract: *Objective:* This study aimed to document the cognitive aftereffects of exposure to uncoupled motion and the time course of recovery from these aftereffects.
Background: Uncoupled motion refers to a situation in which an individual is simultaneously exposed to two asynchronous motions, either real or virtual. These environments are a challenge for designers because technology that is supposed to increase the user's task performance may actually lead to decreased task performance.
Method: In the study, 11 male participants, (median age = 32 years) with prior flight experience (median = 600 hr) were exposed to an uncoupled motion environment consisting of a flight simulator on a vertically oscillating platform. Participants completed a cognitive test battery, a balance test, and a dynamic visual acuity test preexposure, immediately postexposure, and 2, 4, 6, 8, and 24 hr postexposure.
Results: The uncoupled motion scenario led to significant cognitive aftereffects that cannot be solely attributed to motion sickness. These aftereffects lasted between 2 and 4 hr postexposure. The scenario generated some physiological aftereffects that lasted between 1 and 2 hr postexposure. However, it is likely that these aftereffects can be attributed to motion sickness.
Conclusion: Uncoupled motion can cause unappreciated effects, such as degraded cognitive performance.
Application: System designs that create uncoupled motion need to be evaluated for the potential to generate operator impairment, and designs should be modified to minimize this potential wherever possible. When redesign is not possible, system-use guidelines should be developed to minimize impairment. The current results suggest operators avoid performing cognitively demanding tasks for at least 2 hr postexposure.

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Reference Type: Journal Article
Author: Nahon, M. A.; Reid, L. D.; Kirdeikis, J.
Year: 1992
Title: Adaptive simulator motion software with supervisory control
Journal: Journal of Guidance, Control, and Dynamics
Volume: 15
Issue: 2
Pages: 376-383
Electronic Resource Number: AIAA-90-3133-CP
Author's Title and Affiliation: Nahon: Student Member of AIAA, University of Ontario, Institute for Aerospace Studies, Downsview, Ontario, Canada M3H 5T6
Reid: Associate Fellow of AIAA, University of Ontario, Institute for Aerospace Studies, Downsview, Ontario, Canada M3H 5T6
Number of Pages: 9
Keywords: adaptive simulator motion software, supervisory control, washout filters
Abstract: Concepts for flight simulator motion-drive algorithms range from the most basic to the relatively complex, with little to guide a choice between these, short of implementing them all and choosing the best. In order to avoid this lengthy process and put into practice the experience gained in a previous large-scale evaluation exercise, a flexible motion algorithm has been implemented. It can be run as a simple classical algorithm with few free parameters, and can be quickly adjusted to yield good motion performance. The more sophisticated adaptive features of the algorithm can then be brought in gradually to improve performance. Various forms of cost functions and adaptive features were investigated. These were tested on a synergistic 6 degrees-of-freedom motion-base simulator and promising features were identified. Finally, a supervisory code was included to ease motion adjustment, and to provide a safe interactive interface with the designer, as well as automatic motion adjustment to different flight conditions.

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Reference Type: Conference Paper
Author: Nahon, Meyer A.; Ricard, Rémi; Gosselin, Clément
Year: 1995
Title: Making it real - A comparison of flight-simulator motion-base architectures
Conference Name: CEAS Symposium on Simulation Technology
Date: October 30-November 1
Electronic Resource Number: MSy02
Author's Title and Affiliation: Nahon: Department of Mechanical Engineering, University of Victoria, Victoria, B.C., Canada
Ricard and Gosselin: Département de Génie Méchanique, Université Laval, Québec, Québec, Canada
Abstract: This paper presents a comparison of four different six-degree-of-freedom architectures for use as flight simulator motion platforms. The architectures included in this study are the conventional 'Stewart Platform', as well as three others in which the actuator attachment points are altered. These architectures are compared on the basis of their kinematic properties, such as workspace and rigidity, and in terms of their ability to simulate a particular aircraft maneuver. The comparison of the kinematic properties of the different architectures is performed using a specialized CAD tool developed for the kinematic analysis and optimization of parallel mechanisms. The performance of each architecture as a flight simulator motion platform is evaluated using a Boeing 747 aircraft simulation coupled to classical motion washout filters. Although no architecture proved to be better than all the others in all respects, particular architectures do excel in particular performance measures. Overall, the Stewart platform exhibited the most balanced performance.

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Reference Type: Journal Article
Author: Nakamura, Shinji; Shimojo, Shinsuke
Year: 1999
Title: Critical role of foreground stimuli in perceiving visually induced self-motion (vection)
Journal: Perception
Volume: 28
Pages: 893-902
Author's Title and Affiliation: Nakamura: Future Project Division, Toyota Motor Corporation 1200 Mishuku, Susono, Shizuoka, 410-1193 Japan
Shimojo Computation and Neural Systems, California Institute of Technology, 139-74 Pasadena, CA 91125, USA
Keywords: vection, illusory self-motion, foreground stimuli, background stimuli
Abstract: The effects of a foreground stimulus on vection (illusory perception of self-motion induced by a moving background stimulus) were examined in two experiments. The experiments reveal that the presentation of a foreground pattern with a moving background stimulus may affect vection. The foreground stimulus facilitated vection strength when it remained stationary or moved slowly in the opposite direction to that of the background stimulus. On the other hand, there was a strong inhibition of vection when the foreground stimulus moved slowly with, or quickly against, the background. These results suggest that foreground stimuli, as well as background stimuli, play an important role in perceiving self-motion.
URL:
http://wexler.free.fr/library/files/nakamura%20(1999)%20critical%20role%20of%20foreground%20stimuli%20in%20perceiving%20visually%20induced%20self-motion%20(vection).pdf
Author Address: snakamur@square.mk.toyota.co.jp
Access Date: August 15, 2007

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Reference Type: Journal Article
Author: Nakamura, Tadashi; Bronstein, Adolfo M.
Year: 1995
Title: The perception of head and neck angular displacement in normal and labyrinthine-defective subjects: A quantitative study using a 'remembered saccade' technique
Journal: Brain: A Journal of Neurology
Volume: 118
Issue: 5
Pages: 1157-1168
ISSN: 0006-8950 (Print)
1460-2156 (Electronic)
Number of Pages: 12
Accession Number: 1996-31320-001
Keywords: detection of horizontal or angular displacement of head or trunk, 45-60 yr olds with labyrinthine defects
Abstract: The detection of horizontal angular displacement of the head or trunk was assessed in 13 normal subjects and three labyrinthine defective patients. Discrete rotational displacements to the whole body (vestibular stimulus, VS), the trunk whilst keeping the head earth-stationary (cervical stimulus, CS) or the head upon the stationary trunk (combined VS+CS in passive and active mode) were delivered. Amplitudes ranged from 10° to 40° with peak velocities from 5° to 40°/s. Response was quantified as saccadic gain (final position of the eye/amplitude of the rotational stimulus) in a 'remembered saccade' task. It was found that normal subjects show different accuracy according to the sensory channel investigated. If stimulus amplitude was limited (20-30°), gain dropped as rotational velocity decreased during VS but not in conditions including cervical stimulation (CS or VS+CS). Responses combining cervical and vestibular stimuli (VS+CS) were closer to unity gain and showed less scatter than isolated VS and CS. In the labyrinthine-defective patients, VS yielded no structured response but all responses involving cervical stimulation were identical to those of normal subjects when analysed both as a function of stimulus amplitude and velocity. Neither in normal nor in labyrinthinedefective subjects were there

significant differences in the ability to detect head angular displacement between passive or active head turns (passive or active VS+CS). The following conclusions can be made, (i) 'Remembered saccade' techniques can be used to investigate cervico-vestibular perception, (ii) The 'high pass' characteristic of the response during VS agrees with the dynamic sensitivity of the vestibular nerve signals. Cervical experiments confirmed that neck responses are position-driven (i.e. 'tonic'). (iii) The detection of head turns is only slightly more accurate when vestibular and cervical signals are combined, but the main input controlling this perception is provided by neck afferents. No specific function for 'efference copy' was apparent in these experiments, (iv) There is no significant change for detecting head turns (on the trunk) in labyrinthine-defective patients. (v) The lack of detectable changes in cervical tasks in labyrinthine-defective patients does not support the view that the potentiation of the cervico-ocular reflex (COR) observed in these patients is due to enhanced sensitivity of the neck afferent system.

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Reference Type: Web Page
Author: NASA Ames Research Center
Year: 2005
Title: SimLab Vertical Motion Simulator
Publisher: National Aeronautics and Space Administration (NASA)
Access Date: July 31, 2008
Description: Overview of Vertical Motion Simulator (VMS)
Last Update Date: April 25, 2005
Abstract: At NASA Ames Research Center, in California's Silicon Valley, scientists conduct advanced research in a unique flight simulation complex. The facility provides researchers with exceptional tools to explore, define, and solve issues in both aircraft and spacecraft design. It offers fast and cost-effective solutions using real-time piloted simulation, realistic sensory cues, and the greatest motion range of any flight simulator in the world.
URL: http://www.simlabs.arc.nasa.gov/vms/vms.html

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Reference Type: Magazine Article
Author: NASA Aviation Safety Reporting System (ASRS)
Year: 1998
Title: Blow off the cobwebs
Magazine: ASRS Callback; A Monthly Safety Bulletin from The Office of the NASA Aviation Safety Reporting System
Issue Number: 227
Date: May
Type of Article: Newsletter
Author's Title and Affiliation: P.O. Box 189, Moffett Field, CA 94035-0189
Abstract: Even highly-qualified pilots are prone to mistakes if they lack recent flight experience, as an air carrier First Officer learned on a flight with a company Flight Manager.
URL: http://asrs.arc.nasa.gov/publications/callback/cb_227.htm

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Reference Type: Web Page
Author: NASA Dryden Flight Research Center
Year: 2006
Title: Intelligent flight control system
Access Date: August 25, 2008
Description: NASA Dryden Fact Sheet
Last Update Date: February 13, 2006
Keywords: intelligent flight control system (IFCS), upset recovery training (URT)
URL: http://www.nasa.gov/centers/dryden/news/FactSheets/FS-076-DFRC_prt.htm

Reference Type: Report
Author: NASA Research Mission Directorate Aviation Safety Program
Year: 2007
Title: Integrated resilient aircraft control
Institution: NASA
Type: draft research plan
Author's Title and Affiliation: Principal Investigator: Joseph Totah
Project Scientist: Kalmanje Krishnakumar
Project Manager: Sally Viken
Keywords: integrated resilient aircraft control (IRAC), upset recovery training (URT)

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Reference Type: Conference Proceedings
Author: Naseri, Amir; Grant, Peter R.; Dufort, Paul
Year of Conference: 2008
Title: Modeling the perception of acceleration and jerk using signal detection theory
Conference Name: AIAA Modeling and Simulation Technologies Conference
Conference Location: Honolulu, HI
Publisher: American Institute of Aeronautics and Astronautics (AIAA)
Date: August 18-21
Author's Title and Affiliation: Institute for Aerospace Studies, University of Toronto, Toronto, Canada
Abstract: A recent flight simulator study was performed to investigate the effect of jerk and acceleration on the perception of motion strength. The paired comparison methodology was used to compare nine different motion time histories in surge with varying levels of jerk and acceleration. The analysis of the paired comparison showed that both jerk and acceleration contributed significantly to the perceived strength of motion. In this paper the results of this experiment are compared with the predictions of a proposed signal-in-noise detection model. The model assumes that motion signals are disturbed by a gaussian noise in the human vestibular system.
Author Address: 4925 Dufferin St., Toronto, ON, M3H 5T6

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Reference Type: Magazine Article
Author: Nash, Trevor
Year: 1997
Title: A changing industry?
Magazine: Journal for Civil Aviation Training (CAT)
Volume: 8
Issue Number: 4
Author's Title and Affiliation: Editor-in Chief, Journal for Civil Aviation Training
Number of Pages: 1
Keywords: US Advanced Qualification Program (AQP), Ro-Ro concept, FFS shell, FTD
Notes: "CAT comment" section of the journal.

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Reference Type: Report
Author: Nataupsky, Mark; Waag, Wayne L.; Weyer, Douglas C.; McFadden, Robert W.; McDowell, Edward
Year: 1979
Title: Platform motion contributions to simulator training effectiveness: Study III--interaction of motion with field-of view
City: Williams Air Force Base, AZ
Institution: Flying Training Division, Air Force Human Resources Laboratory
Type: Final Report (Technical)

Report Number: AFHRL-TR-79-25
Recipient's Title and Affiliation: HQ Air Force Human Resources Laboratory (AFSC)
Keywords: field of view, motion simulation, platform motion, training effectiveness, transfer of training, visual simulation
Abstract: The objective was to determine the effects of platform motion cueing, visual field of view, and their interaction upon learning in the simulator and as subsequent transfer of training to the aircraft for basic contact maneuvers in the T-37 aircraft. A transfer-of training study design was used in which student pilots were initially trained in the Advanced Simulator for Pilot Training and subsequently evaluated on their first sortie in the T-37 aircraft. Each student received training under one of four simulator configurations: (a) full platform motion (six degrees of freedom), full FOV (300 horizontal by 150 vertical); (b) full platform motion, limited FOV (48 horizontal by 36 vertical); (c) no platform motion, full FOV; and (d) no platform motion, limited FOV. For the ASPT pretraining phase, scores from the automated performance measuring system and overall instructor pilot ratings were used for analysis. For the T-37 evaluation sorties, the overall instructor pilot ratings, as well as individually recorded flight parameters, were analyzed. These data provided no conclusive evidence of differential transfer effects resulting from platform motion cueing, size of the visual FOV, or their interaction. As such, these data provide support for previous findings that platform motion cueing does not significantly enhance the transfer of learning for basic contact tasks in the T-37 aircraft. It would seem that the impact of peripheral visual cues for initial acquisition is not critical. Furthermore, no convincing evidence was found indicating increased transfer using platform motion in conjunction with a narrow FOV visual scene. The major implication from these findings is that a fixed-base, limited FOV simulator configuration provides sufficient cueing for basic contact skills normally trained during Undergraduate Pilot Training.

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Reference Type: Web Page
Author: National Aeronautics and Space Administration (NASA)
Year: 1992
Title: Making the skies safer from windshear
Access Year: 2008
Access Date: July 10
Description: NASA Fact Sheet
Keywords: windshear detection and avoidance system
Abstract: NASA's Langley Research Center is part of a joint NASA and Federal Aviation Administration (FAA) effort to develop technology for the airborne detection of windshear, a hazardous weather condition that has been blamed for the loss of hundreds of lives in airplane crashes.
URL: http://www.nasa.gov/centers/langley/news/factsheets/Windshear.html

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Reference Type: Web Page
Author: National Air Traffic Services (NATS)
Year: 2006
Title: New tower is virtually real for Heathrow air traffic control
Access Year: 2007
Access Date: Feb. 5
Description: News
Last Update Date: May 5, 2006
Type of Medium: Website News Release
Number of Pages: 2
Abstract: One of Europe's most realistic air traffic control (ATC) simulators has gone live, preparing controllers at Heathrow for life in their new tower, 87 meters above the runways of the world's busiest international airport.
URL:
http://www.nats.co.uk/article/219/72/new_tower_is_virtually_real_for_heathrow_air_traffic_control_.html

Reference Type: Report
Author: National Transportation Safety Board
Year: 2004
Title: In-flight separation of vertical stabilizer, American Airlines Flight 587, Airbus Industrie A300-605R, N14053, Bell Harbor, New York, November 12, 2001
City: Washington, D. C.
Institution: National Transporation Safety Board
Document Number: PB2004-910404
Pages: 1-212
Date: October 26, 2004
Type: Accident report
Report Number: NTSB/AAR-04/04
Number of Pages: 212
Abstract: This report explains the accident involving American Airlines flight 587, an Airbus Industrie A300-605R, N14053, which crashed into a residential area of Belle Harbor, New York, following the in-flight separation of the airplane's vertical stabilizer and rudder. The safety issues discussed in this report focus on characteristics of the A300-600 rudder control system design, A300-600 rudder pedal inputs at high airspeeds, aircraft-pilot coupling, flight operations at or below an airplane's design maneuvering speed, and upset recovery training programs. Safety recommendations concerning these issues are addressed to the Federal Aviation Administration and the Direction Général de l'Aviation Civile.
URL: http://www.ntsb.gov/publictn/2004/AAR0404.pdf

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Reference Type: Report
Author: National Transportation Safety Board
Year: 2010
Title: Loss of control on approach, Colgan Air, Inc., operating as Continental Connection flight 3407, Bombardier DHC-8-400, N200WQ, Clarence Center, New York, February 12, 2009
City: Washington, D. C.
Institution: National Transportation Safety Board
Document Number: NTSB/AAR-10/01
PB2010-910401
Pages: 1-299
Date: February 2, 2010
Type: Accident Report
Report Number: NTSB/AAR-10/01
Number of Pages: 299
Abstract: This report discusses the accident involving a Colgan Air, Inc., Bombardier DHC-8-400, N200WQ, operating as Continental Connection flight 3407, which experienced a loss of control on an instrument approach to Buffalo-Niagara International Airport, Buffalo, New York, and crashed into a residence in Clarence Center, New York, about 5 nautical miles northeast of the airport. The safety issues discussed in this report focus on strategies to prevent flight crew monitoring failures, pilot professionalism, fatigue, remedial training, pilot training records, airspeed selection procedures, stall training, Federal Aviation Administration (FAA) oversight, flight operational quality assurance programs, use of personal portable electronic devices on the flight deck, the FAA's use of safety alerts for operators to transmit safety-critical information, and weather information provided to pilots. Safety recommendations concerning these issues are addressed to the FAA.
URL: http://ntsb.gov/Publictn/2010/AAR1001.pdf

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Reference Type: Report
Author: National Transportation Safety Board (NTSB)
Year: 1994
Title: Safety study: Commuter Airline Safety
City: Washington, DC
Pages: 1-133
Date: November 15
Report Number: NTSB Report Number: SS--94-02
NTIS Report Number: PB94-917004
Number of Pages: 133
Keywords: Commuter Rule, One Level of Safety
Abstract: [Executive Summary] The commuter airline industry has grown dramatically and has experienced significant changes in operating characteristics in the past 15 years. In 1993, over 52 million passengers flew on aircraft with 60 or fewer passenger seats. Commuter airlines are increasingly introducing larger, more sophisticated airplanes into their fleets. Additionally, a proliferation of code-sharing arrangements in recent years has given rise to coordinated air service between major air carriers and commuter airlines.
Because commuter airlines evolved from the air taxi segment of the commercial aviation industry, many of the regulatory standards that apply to commuter airline operations differ from those that apply to major air carrier operations. Scheduled passenger service in aircraft containing more than 30 passengers is subject to the safety standards in Title 14 Part 121; operations in aircraft containing 30 seats or fewer are subject to the less stringent standards in Part 135.
The National Transportation Safety Board has had a long standing interest in commuter airline safety and has issued safety recommendations in the past seeking various actions by government and industry to address needed safety improvements. The recommendations followed the Board's 1972 study of air taxi safety, its 1980 study of commuter airline safety, and investigations of accidents involving commuter airline operations. In response to the recommendations and through other initiatives taken by government and industry, regulatory revisions and other actions have resulted in a greatly improved safety record for scheduled Part 135 airlines: the accident rate per 100,000 departures in 1993 was one-forth the accident rate observed in 1980.
However, despite past efforts of government and industry to bring about safety improvements, accident rates for commuter airlines continue to be twice as high as the rates for domestic Part 121 airlines. The higher accident rate demonstrated by commuter airlines, the different regulatory standards in the commercial aviation industry, and findings of the Safety Board's investigations of recent accidents involving commuter airline operations have heightened concerns by government and industry about the safety of the commuter airline industry and the adequacy of Part 135 regulations. These issues and concerns prompted the Safety Board to initiate this study of commuter airline safety. The purpose of the study was to examine the standards and practices of the commuter airline industry, with particular emphasis on areas where changes have occurred since the Board's 1980 study and where regulatory standards differ for Part 135 and Part 121 operations.
The study used data and information from the following sources: (a) onsite interviews conducted in the spring of 1994 with airline management, pilots, flight attendants, and mechanics at 21 commuter airlines; (b) information from a 3-day public forum on commuter airline safety held in June 1994 with participants from government, airlines, trade groups, labor unions, aircraft manufacturers, and training centers; and (c) information from the Safety Board's accident investigations and previous studies on the air taxi/commuter airline industry. The Board examined the current standards and practices of the commuter airline industry relevant to the safety issues and concerns in several broad areas: flightcrew scheduling and dispatching; flightcrew training and qualifications; aircraft maintenance and inspection; cabin safety and airport certification; aircraft certification and equipment requirements; airline management oversight; and FAA surveillance. The Board also reviewed pertinent Federal regulations, especially where differences occur between the requirements for Part 135 and Part 121 operations, and initiatives being taken to address the issues and concerns.
The safety issues discussed in the study are:
- The need for sweeping regulatory action to address changes in the operating characteristics of the commuter airline industry.
- The adequacy of Part 135 regulations concerning flight time limits and rest requirements.

- The pressures on pilots to accomplish necessary tasks between flights in shorter periods of time without support from licensed dispatch personnel.
- The adequacy of pilot training, including the need for mandatory crew resource management training, the use of contract and simulator training, and operating experience requirements.
- The adequacy of flight attendant training on emergency procedures, and the need for joint crew resource management for cockpit/cabin crew.
- The need for mandated safety programs at commuter airlines that included an independent safety function, and for operational oversight by major air carrier code-sharing partners that includes safety audits.
- The training of Federal Aviation Administration inspectors and lack of uniform interpretation and enforcement of regulations by inspectors.
- The certification of airports served by scheduled passenger operations.

As a result of the safety study, recommendations concerning these issues were made to the Federal Aviation Administration, the U.S. Department of Transportation, major U.S. domestic air carriers, and the Regional Airline Association.
URL: http://amelia.db.erau.edu/reports/ntsb/ss/SS94-02.pdf

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Reference Type: Electronic Article
Author: National Transportation Safety Board (NTSB)
Year: 2001
Title: Update on NTSB investigation into crash of American Airlines flight 587
Periodical Title: NTSB News
Issue: Advisory
Author's Title and Affiliation: NTSB Advisory, Washington, DC 20594
Keywords: American Airlines flight 587, upset recovery training (URT)
Abstract: On November 12, 2001, at approximately 9:17 a.m., American Airlines flight 587, an Airbus A-300-600, N14053, crashed into a neighborhood in Belle Harbor, New York, several minutes after taking off from Kennedy International Airport. The plane was on a scheduled flight to Santo Domingo, Dominican Republic. All 260 persons aboard the plane died, as did 5 on the ground. The following is an update of factual information developed during the Safety Board's investigation.
Notes: Press Release dated November 20, 2001.
URL: http://www.ntsb.gov/Pressrel/2001/011120.htm
Updates 2-12: http://www.ntsb.gov/events/2001/AA587/default.htm
Access Date: October 16, 2006

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Reference Type: Aircraft Accident Report
Author: National Transportation Safety Board (NTSB)
Year: 2004
Title: In-flight separation of vertical stabilizer American Airlines flight 587 Airbus industrie A300-605R, N14053 Belle Harbor, New York November 12, 2001
City: Washington, DC
Date: October 26
Report Number: NTSB/AAR-04/04
Keywords: American Airlines flight 587, upset recovery training (URT)
Abstract: This report explains the accident involving American Airlines flight 587, an Airbus Industrie A300-605R, N14053, which crashed into a residential area of Belle Harbor, New York, following the in-flight separation of the airplane's vertical stabilizer and rudder. The safety issues discussed in this report focus on characteristics of the A300-600 rudder control system design, below an airplane's design maneuvering speed, and upset recovery training programs. Safety recommendations concerning these issues are addressed to the Federal Aviation Administration and the Direction Générale de l'Aviation Civile.
URL: http://www.ntsb.gov/publictn/2004/AAR0404.pdf

Reference Type: Book Section
Author: Naval Aerospace Medical Institute (NAMI)
Year: 1991
Title: Disorientation not attributable to strong vestibular stimuli - Primacy of vision
Editor: Naval Aerospace Medical Institute (NAMI)
Book Title: United States Naval Flight Surgeon's Manual
Edition: 3rd
Number of Pages: 5
Keywords: upset recovery training (URT), disorientation
Abstract: (taken from introduction paragraph) Many of the disorienting conditions described in previous sections would be considerably ameliorated or overcome by good visual reference to the Earth's surface. The single most important cause of pilot disorientation is the absence of adequate visual reference to the Earth because of darkness or adverse weather conditions. Certain flying conditions can introduce visual information that may be either directly disorienting or misinterpreted, but the crucial factor in the human response it that, without good visual reference to Earth's surface, the remaining sensory data on spatial disorientation are not sufficiently reliable to permit safe piloting of aircraft. This was nicely demonstrated by Krause (1959) who measured times from occlusion of pilots' visual reference until the aircraft assumed a condition requiring 10,000 feet for recovery. Following banks and turns, time were typically 20 to 30 seconds, but even after level flight, mean times were on the order of 60 seconds. Many instances of pilot disorientation are less attributable to some overwhelming misleading vestibular response than to some subtle perceptual inconsistency or even to perceptual insensitivity to the acceleration environment.

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Reference Type: Conference Paper
Author: Nelson, W. T.; Bolia, R. S.; McKinley, R. L. Chelette, T. L.; Tripp, L. D.; Esken, R. L.
Year: 1998
Title: Localization of virtual auditory cues in high +G_z environment
Conference Name: Human Factors and Ergonomics Society 42nd Annual Meeting
Author's Title and Affiliation: Nelson, McKinley, Chelette, Esken: Air Force Research Laboratory, Wright-Patterson AFB, OH 45433
Bolia, Tripp: Veridian, 5200 Springfield Pike, Dayton OH 45431-1289
Number of Pages: 23
Abstract: The ability to localize a virtual auditory source was evaluated under varying levels of sustained (+Gz) acceleration. Participants were required to judge the locations of virtual auditory cues located along the horizontal plane (elevation 0°) during exposure to 1.0, 1.6, 2.5, 4.0, 5.6, and 7.0 +Gz. The experiment was conducted at the Air Force Research Laboratory’s Dynamic Environment Simulator - a man-rated, three-axis centrifuge. No significant increases in localization error were found between 1.0 and 5.6 +Gz; however, a significant increase did occur at the 7.0 +Gz level. In addition, the percentage of reversals did not vary as a function of +Gz level. Collectively, these results indicate that one’s ability to localize virtual auditory cues is well maintained at various levels of sustained acceleration.
URL: http://handle.dtic.mil/100.2/ADA430341

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Reference Type: Conference Paper
Author: Neville, Kendall W.
Year: 1996
Title: More cost effective method for update and validation of simple derivative simulations
Conference Name: Training: Lowering the Cost, Maintaining the Fidelity
Conference Location: London
Publisher: Royal Aeronautical Society (RAeS)
Date: May 15-16
Author's Title and Affiliation: Boeing Commercial Airplane Group, Seattle, WA
Number of Pages: 10

Abstract: Since the establishment of the FAA Advanced Simulation Plan in the early 1980's, qualification of high-level training simulators has required an extensive quantitative comparison of simulator and aircraft data. The requirement for direct comparison to flight data has played a major role in the greatly improved fidelity and increased training credit possible for high-level simulators. However, this improved fidelity has been accompanied by a substantial increase in the cost to the data provider for developing simulator data bases and software models. This paper will show that for a simple derivative airplane model where the only significant difference relative to a new or major derivative model is a change in fuselage length, analytical methods may be used to supplement a reduced flight validation program to produce an equivalent flight-updated simulation, thus avoiding much of the cost associated with the full flight update and validation process. The primary source of validation data for a simple derivative model would be the aircraft manufacturer's engineering simulator.

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Reference Type: Report
Author: Newman, David G.
Year: 2007
Title: An overview of spatial disorientation as a factor in aviation accidents and incidents
Series Title: ATSB Transport Safety Investigation Report
City: Canberra City, Australia
Institution: Australian Transportation Safety Bureau (ATSB)
Date: December 3
Report Number: B2007/0063
Author's Title and Affiliation: MB, BS, DAvMed, PhD, MRAeS, FAUCD, AFAIM
Consultant in Aviation Medicine, Flight Medicine Systems Pty Ltd
Number of Pages: 44
Keywords: upset recovery training (URT)
Abstract: Spatial disorientation (SD) is among the most common factors contributing to aviation accidents and incidents, but its true prevalence is difficult to establish. This is because many accidents where SD is cited as a likely factor are fatal, and therefore its role cannot be known with any certainty, but also because in the many instances of SD where an accident doesn't result, it goes unreported.
This study provides a comprehensive explanation of the various types of SD in the aviation environment, and suggests strategies for managing the risk associated with SD events. This report provides an informative overview of the three basic types of SD, and the circumstances under which disorientation might be more likely. These are of value to all pilots, and especially those who conduct flights in instrument conditions or at night under visual flight rules. Single-pilot operations, particularly where an autopilot is not available, face additional risks and the need to identify and manage SD events.
This report also encourages pilots who have experienced SD episodes to share their experiences with their aviation colleagues, either informally, or through magazines, journals, and web-based forums. This will serve to encourage a greater awareness of the incidence of SD, and help reduce the stigma that some pilots might associate with these events. As other studies suggest, SD is likely to be encountered by all pilots during the course of a lifetime's flying - whether professional or non-professional, experienced or inexperienced. A more open approach to acknowledging and discussing SD and its various causes will make a valuable contribution to a better understanding of this common human factor.
URL: http://www.atsb.gov.au/publications/2007/B20070063.aspx

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Reference Type: Book Section
Author: Newman, Richard L.; Haworth, Loran A.
Year: 2004
Title: Flight displays II: Head-up and helmet mounted displays
Editor: Previc, Fred H.; Ercoline, William R.
Book Title: Spatial Disorientation in Aviation
City: Reston, VA
Publisher: American Institute of Aeronautics and Astronautics (AIAA)

Volume: 203
Pages: 451-507
Chapter: 10
Series Editor: Zarchan, Paul
Series Title: Progress in Astronautics and Aeronautics
Author's Title and Affiliation: Newman: Crew Systems, San Marcos, TX
Haworth: FAA, Seattle, WA
Keywords: flight displays, head-mounted displays (HMD), head-up displays (HUD)

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Reference Type: Conference Proceedings
Author: Niccolini, M.; Pollini, L.; Innocenti, M.; Giordano, Paolo Robuffo; Teufel, Harald J.; Bülthoff, Heinrich H.
Year of Conference: 2009
Title: Towards real-time aircraft simulation with the MPI motion simulator
Conference Name: AIAA Modeling and Simulation Technologies Conference
Conference Location: Chicago, IL
Publisher: AIAA
Pages: 1-10
Date: Aug. 10-13
Electronic Resource Number: AIAA 2009-5918
Author's Title and Affiliation: Niccolini: PhD student, Dept of Electrical Systems and Automation, University of Pisa, Pisa, Italy
Pollini: Assistant Professor, Dept of Electrical Systems and Automation, University of Pisa, Pisa, Italy
Innocenti: Professor, Dept of Electrical Systems and Automation,University of Pisa, Pisa, Italy
Giordano: Research Scientist, Max Planck Institute for Biological Cybernetics, Tübingen, Germany
Teufel: Research Assistant, Max Planck Institute for Biological Cybernetics, Tübingen, Germany
Bülthoff: Director, Max Planck Institute for Biological Cybernetics, Tübingen, Germany
Number of Pages: 10
Keywords: motion platform, Stewart platform, anthropomorphic robot actuation system
Abstract: The paper describes the recent advancements gained on the MPI motion simulator project. The aim of this project is the use of an anthropomorphic robot as an actuation system for a motion platform intended for real time flight simulation. Almost all commercially available motion platforms rely on the so called Stewart platform, that is a 6-DOF platform that can bear high payloads and can achieve high accelerations. On the other hand an anthropomorphic manipulator offers a larger range of motion and higher dexterity, that let envisage this novel motion simulator as a viable and superior alternative. The paper addresses the use of a new inverse kinematics algorithm capable of keeping joint velocities and accelerations within their limits. Preliminary experimental results performed using the proposed algorithm along with possible further improvements are discussed.

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Reference Type: Journal Article
Author: Nickerson, R. S.
Year: 1973
Title: Intersensory facilitation of reaction time: Energy summation or preparation enhancement?
Journal: Psychological Review
Volume: 80
Issue: 6
Pages: 489-509
Date: November
Author's Title and Affiliation: Bolt Beranek and Newman Inc., Cambridge, MA
Number of Pages: 21
Abstract: Some recent studies of intersensory facilitation of reaction time are reviewed. The finding of interest is that reaction time to a primary (usually visual) stimulus can be shortened if an accessory

(usually auditory) stimulus is presented at approximately the same time. This is true when the accessory stimulus is defined as irrelevant in the sense that the subject need not attend to it in order to perform the task, and he is not to respond to it when it occurs alone. Energy summation across modalities and preparation enhancement have been suggested as two factors that play roles in facilitation, and the position has been taken that both concepts are necessary to account for all the results. The argument is made in this article that it is not necessary to invoke both concepts because a preparation-enhancement hypothesis can account for all the findings that can be explained by an energy-summation hypothesis, and other findings as well.

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Reference Type: Conference Proceedings
Author: Nieuwenhuizen, F.M.; Beykirch, K.A.; Mulder, M.; Bülthoff, H.H.
Year of Conference: 2007
Title: Identification of pilot control behavior in a roll-lateral helicopter hover task
Conference Name: AIAA Modeling and Simulation Technologies Conference and Exhibit
Conference Location: Hilton Head, SC
Publisher: American Institute of Aeronautics and Astronautics (AIAA)
Electronic Resource Number: AIAA 2007-6799
Author's Title and Affiliation: Nieuwenhuizen: PhD student, Max Planck Institute for Biological Cybernetics, P.O. Box 2169, 72012 Tübingen, Germany
Beykirch: Research Scientist, Max Planck Institute for Biological Cybernetics, P.O. Box 2169, 72012 Tübingen, Germany
Mulder: Associate Professor, Control and Simulation Division, Faculty of Aerospace Engineering, Delft University of Technology, P.O. Box 5058, 2600GB, Delft, the Netherlands
Bülthoff: Professor, Max Planck Institute for Biological Cybernetics, P.O. Box 2169, 72012 Tübingen, Germany
Abstract: This paper focuses on the influence of different forms of motion feedback on the perception and control behavior of pilots in a roll-lateral helicopter hover task. To identify this influence, a combined target-following and disturbance-rejection task is carried out where the motion feedback is visual. The participants perform the control task with roll motion only, lateral motion only, combined roll-lateral motion, or with no motion. A cybernetic approach is taken to identify multi-loop pilot describing functions and estimate the parameters of a pilot model. Results show that participants perform significantly better at the control task with feedback of combined roll-lateral motion, and decrease their control activity. For the condition with feedback of roll motion a similar trend is observed. This is explained through the increased amount of information present in the inner roll stabilization loop.
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Reference Type: Conference Proceedings
Author: Nieuwenhuizen, F.M.; van Paassen, M.M.; Mulder, M.; Beykirch, K.; Bülthoff, H.H.
Year of Conference: 2009
Title: Towards simulating a mid-size Stewart platform on a large hexapod simulator
Conference Name: AIAA Modeling and Simulation Technologies Conference
Conference Location: Chicago, IL
Publisher: American Institute of Aeronautics and Astronautics (AIAA)
Pages: 1-10
Date: Aug. 10-13
Electronic Resource Number: AIAA 2009-5917
Author's Title and Affiliation: Nieuwenhuizen: Ph.D. candidate, Max Planck Institute for Biological Cybernetics, Tübingen, Germany

van Paassen: Associate Professor, Control and Simulation Division, Faculty of Aerospace Engineering, Delft University of Technology, Delft, The Netherlands
Mulder: Professor, Control and Simulation Division, Faculty of Aerospace Engineering, Delft University of Technology, Delft, The Netherlands
Beykirch: Research Scientist, Max Planck Institute for Biological Cybernetics, Tübingen, Germany
Bülthoff: Professor and Director, Max Planck Institute for Biological Cybernetics,Tübingen, Germany
Number of Pages: 10
Keywords: MPI, Stewart platform, hexapod simulator
Abstract: For a recent project on the influence of motion system characteristic on human perception and control behavior, a dynamic model of the MPI Stewart platform was developed. The model parameters were estimated from measurements involving motion along a circular trajectory and frequency sweeps. Simulation results showed that the model response with optimized parameters was very close to the measured platform response. However, additional measurements are required to identify the platform mass and vertical center of gravity position correctly. Validation of the dynamic model with platform measurements in heave showed favorable results. The dynamic model of the MPI Stewart platform will be validated further in multiple degrees-of-freedom and will be used in active closed-loop experiments.

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Reference Type: Workshop/Symposia
Author: Noon, Hank; Murphy, Miles
Year of Workshop: 1983
Title: Innovative approaches to recurrent training
Workshop Name: Flight Training Technology for Regional/Commuter Airline Operation
Workshop Location: Moffett Field, CA
Publisher: National Aeronautics and Space Administration (NASA), Ames Research Center
Date of Workshop: September 28-30
Author's Title and Affiliation: Noon: Command Airways
Murphy: NASA
Keywords: recurrent training, cockpit resource management, guidelines
Abstract: (from first page) The first thing we did was to question whether recurrent training is necessary. It was unanimously reaffirmed that there is a need for recurrent training, and that it is a very important element in every training program.
We tried to set down some objectives of recurrent training. The first one is to fulfill legal requirements. The second is to fit the needs of the airlines, and in this regard, we felt that it may require some type of petition to change FAR's so that innovation is encouraged, and I think that RAA has already started to work on that. So we didn't go any further.
Number three is that incorporation of cockpit resource management is an absolute necessity.
Number four is program guidelines. Needs and objectives derived from analysis, including cockpit resource management must be developed and incorporated.

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Reference Type: Conference Paper
Author: Norré, Marcel E.
Year: 1987
Title: Cues for training vertigo, providing suggestions for the management of simulator sickness
Conference Name: Aerospace Medical Panel Symposium on Motion Cues in Flight Simulation and Simulator Induced Sickness
Conference Location: Brussels, Belgium
Publisher: Advisory Group for Aerospace Research and Development (AGARD)
Date: September 29
Author's Title and Affiliation: M.D., Ph.D., Department of Otoneurology & Equilibriometry, The University of Leuven Hospitals, Leuven, Belgium
Number of Pages: 4
Keywords: vertigo, simulator sickness, vestibular, sensory mismatch

Abstract: (first paragraph) Clinical experience with exercise treatment for vertigo has confirmed the extreme adaptability of the balance system [references]. Vestibular Habituation Training (V.H.T.) for provoked (positioning) vertigo provides some interesting cues in the scope of the theme of this meeting, related to simulator sickness.
URL: http://stinet.dtic.mil/oai/oai?verb=getRecord&metadataPrefix=html&identifier=ADA202492

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Reference Type: Report
Author: North Atlantic Treaty Organization (NATO)
Year: 2000
Title: Flight control design best practices
City: Neuilly-sur-Seine Cedex, France
Institution: Research and Technology Organization (RTO), NATO
Date: January 12
Report Number: RTO Technical Report 29
Author's Title and Affiliation: Task Group SCI-026 on Flight Control Law Design
Recipient's Title and Affiliation: Task group sponsors: AGARD [former] Flight Vehicle Integration Panel; RTO Systems, Concepts and Integration (SCI) Panel
Keywords: flight control, simulation, lessons learned, design, aircraft, best practices, aviation safety, PIO (pilot induced oscillations), handling qualities, aviation accidents, upset recovery training (URT)
Abstract: Accidents due to adverse aircraft-pilot coupling phenomena in the latest technology aircraft occurred both in the US and in Europe, while other programs had less-well-publicized flight control development problems. These events showed that a robust and affordable solution to the development process of digital flight control systems was not universally available. The Technical Report begins with a review of some examples of flight control problems. They span the history of flight from the time when the practice of flying was preceding theoretical developments up to the recent events. There is a chapter detailing lessons learned from various programs with positive results. The review of problems and lessons learned leads into a chapter detailing a series of recommended design best practices. The best practices are laid out as a logical process with recommendations for avoiding the pitfalls that have led to problems in the past. The second part of the report continues with some theoretical aspects, such as flying qualities criteria and carefree handling, the latest results from analytical and research activities into PIOs, and modelling and system identification to support the design process. The report concludes with suggestions for required future research.
URL: http://handle.dtic.mil/100.2/ADA387777
Author Address: BP 25, 7 rue Ancelle F92201 Neuilly-sur-Seine Cedex, France

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Reference Type: Conference Paper
Author: Nusseck, H.-G.; Teufel, H.J.; Nieuwenhuizen, F.M.; Bulthoff, H.H.
Year: 2008
Title: Learning system dynamics: Transfer of training in a helicopter hover simulator
Conference Name: AIAA Modeling and Simulation Technologies Conference and Exhibit
Conference Location: Honolulu, Hawaii
Publisher: American Institute of Aeronautics and Astronautics (AIAA)
Date: August 2008
Number of Pages: 11
Abstract: Transfer of training between the simulation of an inert and an agile helicopter dynamic was assessed involving a quasi-transfer design. The focus of this study was to test the ability of flight-naïve subjects to successfully acquire and transfer the skills required to perform lateral sidestep hover maneuvers in a helicopter simulation. The experiments were performed using the MPI Motion Simulator with its ability to realize a highly realistic 1:1 motion representation of a simulated helicopter maneuver. As a result, the amount of training needed to stabilize either an agile or an inert helicopter dynamic did not differ. A clear positive transfer effect was found for the acquired skills from the agile to the inert dynamics but not from the inert to the agile dynamics.

Reference Type: Conference Paper
Author: Nusseck, Manfred; Fleming, Roland; Lagarde, Julien; Bardy, Benoit; Bülthoff, Heinrich H.
Year: 2007
Title: Perception and prediction of simple object interactions
Conference Name: Symposim on Applied Perception in Graphics and Visualization (APGV)
Conference Location: Tübingen, Germany
Publisher: ACM Press
Date: July 26
Author's Title and Affiliation: Nusseck, Fleming, and Bülthoff: Max Planck Institute for Biological Cybernetics
Lagarde and Bardy: University Montpellier
Keywords: perception, interaction, prediction
Abstract: For humans, it is useful to be able to visually detect an object's physical properties. One potentially important source of information is the way the object moves and interacts with other objects in the environment. Here, we use computer simulations of a virtual ball bouncing on a horizontal plane to study the correspondence between our ability to estimate the ball's elasticity and to predict its future path. Three experiments were conducted to address (1) perception of the ball's elasticity, (2) interaction with the ball, and (3) prediction of its trajectory. The results suggest that different strategies and information sources are used for perceiving the object than are used to predicting its future behavior.
URL: http://www.kyb.mpg.de/publications/attachments/apgv07-27_4597[0].pdf

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Reference Type: Book Section
Author: O'Hare, David; Roscoe, Stanley
Year: 1990
Title: Training environments: Instruction and simulation
Book Title: Flight Deck Performance: The Human Factor
City: Ames, Iowa
Publisher: Iowa State University Press

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Reference Type: Book Section
Author: Oman, Charles
Year: 1991
Title: Sensory conflict in motion sickness: An observer theory approach
Editor: Ellis, Stephen R.; Kaiser, Mary K.; Grunwald, Arthur C.
Book Title: Pictorial Communication in Virtual and Real Environments
City: New York
Publisher: Taylor and Francis
Pages: 362-376
Keywords: motion sickness, observer theory, exogenous motion, sensory rearrangement, physiological basis, sensory conflict theory, Kalman filter, orientation brain, emertic brain
Abstract: "Motion Sickness " is the general term describing a group of common nausea syndromes originally attributed to motion-induced cerebral ischemia, stimulation of abdominal organ afferent, or overstimulation of the vestibular organs of the inner ear. Sea-, car- and airsickness are the most commonly experienced examples. However, the discovery of other variants such as Cinerama-, flight simulator-, spectacle- and space sickness in which the normal physical motion of the head and body are absent has led to a succession of "sensory conflict" theories which offer a more comprehensive etiologic perspective. Implicit in the conflict theory is the hypothesis that neural and/or humoral signals orient regions of the brain subserving spatial orientation, and that these signals somehow traverse to other centers mediating sickness symptoms. Unfortunately, our present understanding of the neurophysiological basis of motion sickness is far from complete. No sensory conflict neuron or process has yet been physiologically identified. To what extent can the existing theory be reconciled with current knowledge of the physiology and pharmacology of nausea and vomiting? This paper reviews the stimuli which cause sickness, synthesizes a contemporary observer theory view of the sensory conflict hypothesis, and presents a revised model for the dynamic coupling between the putative conflict signals and nausea magnitude estimates. The use of quantitative models for sensory conflict offers a possible new approach to improving the design of visual and motion systems for flight simulators and other "visual environment" display systems.

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Reference Type: Presentation
Author: Oman, Charles; Benveniste, David; Buckland, Daniel A.; Aoki, Hirofumi; Liu, Andrew M.; Natapoff, Alan; Kozevnikov, Maria
Year: 2006
Title: Incongruent spacecraft module visual verticals affect spatial task performance
Presentation Event: 7th Symposium on the Role of the Vestibular Organs in Space Exploration
Event Location: Noordwijk, the Netherlands
Date: June 8
Author's Title and Affiliation: Massachusetts Institute of Technology (MIT), National Space Biomedical Research Institute (NSBRI)
Keywords: spatial disorientation, upset recovery training (URT)
Abstract: Apollo, Skylab, Mir and ISS crews consistently reported difficulty visualizing spatial relationships between interiors of spacecraft modules whose visual verticals were not co-aligned, and disorientation when transiting between them.
Notes: URL is no longer working (9/30/09).
URL:
http://www.congrex.nl/06a07/presentations/session%2004%20Spatial%20Orientation/04_10_Oman.pdf

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Reference Type: Journal Article
Author: Oman, Charles M.
Year: 1982
Title: A heuristic mathematical model for the dynamics of sensory conflict and motion sickness
Journal: Acta Oto-Laryngologica
Volume: 392
Author's Title and Affiliation: Massachusetts Institute of Technology, Man Vehicle Laboratory, Department of Aeronautics and Astronautics, Cambridge, MA 02139
Number of Pages: 44
Keywords: sensory conflict, motion sickness, vestibular, movement control, autonomic nervous system, mathematical models, biocybernetics, upset recovery training (URT)
Abstract: The etiology of motion sickness is now usually explained in terms of a qualitatively formulated "sensory conflict" hypothesis. By consideration of the information processing task faced by the central nervous system in estimating body spatial orientation and in controlling active body movement using an "inertial model" referenced control strategy, a mathematical model for sensory generation is developed. The model incorporates and extends the models proposed by von Holst, Held, and Reason, and is congruent with multisensory models for spatial orientation developed by Young and coworkers. The model postulates a major dynamic functional role for sensory conflict signals in movement control, as well as in sensory-motor adaptation. It accounts for the role of active movement in creating motion sickness symptoms in some experimental circumstances, and in alleviating them in others. The relationship between motion sickness produced by "sensory rearrangement" and that resulting from external motion disturbances is explicitly defined. A nonlinear conflict averaging model is proposed which describes dynamic aspects of experimentally observed subjective discomfort sensation, and suggests resulting behaviors. The model admits several possibilities for adaptive mechanisms which do not include internal model updating. Further systematic efforts to experimentally refine and validate the model are indicated.

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Reference Type: Journal Article
Author: Oman, C.M.; Kendra, A.; Hayashi, M.; Stearns, M.; Bürki-Cohen, J.
Year: 2001
Title: Vertical navigation displays: Pilot performance and workload during simulated GPS constant angle of descent approaches
Journal: International Journal of Aviation Psychology (IJAP)
Volume: 11
Issue: 1

Pages: 15-31
Abstract: This study compared the effect of alternative graphic or numeric vertical navigation aircraft cockpit displays on horizontal and vertical flight technical error, workload, and subjective preference. Displays included (a) a moving map with altitude range arc; (b) the same format, supplemented with a push-to-see profile view, including a vector flight-path predictor; (c) an equivalent numeric display; and (d) a numeric nonvertical navigation display. Sixteen pilots each flew 4 different approaches with each format in a Frasca 242 simulator. Our vertical navigation displays reduced vertical flight technical error by as much as a factor of 2 without increasing workload. Relative advantages of the graphic formats are discussed.
Notes: The edited version of this paper can be obtained from the publisher, Lawrence Erlbaum Associates: http://www.leaonline.com
URL: http://www.volpe.dot.gov/hf/docs/oijapvna.pdf

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Reference Type: Conference Paper
Author: Orasanu, Judith; Fischer, Ute; McDonnell, Lori K.; Davison, Jeannie; Haars, Keri; Villeda, Eric; VanAken, Christina
Year: 1998
Title: How do flight crews detect and prevent errors? Findings from a flight simulation study
Conference Name: Human Factors and Ergonomics Society, 42nd Annual Meeting
Author's Title and Affiliation: Orasanu: NASA Ames Research Center, Moffett Field, CA
Fischer: Georgia Institute of Technology, Atlanta, GA
McDonnell, Davison, Haars, Villeda, VanAken: San Jose State University/NASA Ames Research Center, Moffett Field, CA
Number of Pages: 5
Abstract: In order for a team to maintain safety in a high-risk engineered environment, its members must monitor each other's behavior, as well as the situation. The advantage of a team structure is that members can support each other, catching errors and preventing problems from developing into serious situations. In its analysis of aviation accidents in which crew behavior played a role, the National Transportation Safety Board (1994) observed that most of those accidents involved "monitoring and challenging" errors. After an error occurred, the crew either failed to detect it or to communicate effectively in order to ameliorate the outcome.
This paper describes a simulator study that examined two factors thought to affect monitoring and challenging: (1) level of physical risk in a developing situation and (2) degree of face threat involved in a challenge. Events were scripted to present errors committed by a confederate pilot (high face threat) or problems developing outside the flight deck (low face threat). Videotapes of performance showed that captains were more assertive and responded earlier than first officers, often preventing the problems from developing. This difference, however, was only evident in high-risk situations. First officers were more sensitive to face threat than captains, indicating a need for techniques to overcome limits to error mitigation in high-face threat situations.

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Reference Type: Report
Author: Orlansky, J.; String, J.
Year: 1977
Title: Cost effectiveness of flight simulators for military training. Vol I: Use and effectiveness of flight simulators
City: Arlington, VA
Institution: Institute for Defense Analyses
Type: IDA Paper
Report Number: No. 1275

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Reference Type: Journal Article
Author: Ortiz, Gustavo
Year: 1994
Title: Effectiveness of PC-based flight simulation
Journal: International Journal of Aviation Psychology (IJAP)
Volume: 4
Issue: 3
Pages: 285-291
Author's Title and Affiliation: Andrews University
Number of Pages: 7
Abstract: PC-based flight-simulation effectiveness was analyzed through a transfer-of-learning study. Sixty college students with no previous flight experience performed a designated-aircraft maneuver. Thirty of the subjects were trained in a computer-based training device (CBTD) before flying; the remaining 30 were taken directly to the aircraft. Chi-square and t-test analyses on the data revealed a statistical advantage at the .01 level of confidence for the CBTD-trained experimental group, which performed significantly better than the control group. The CBTD chosen for this study was AzureSoft's Electronic Instrument Flight Rules Environment (ELITE), run on a Zenith personal computer. Cessna 150 and 152 aircraft in flight training is recommended because they have the potential for reducing the amount of hours spent in the airplane.

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Reference Type: Report
Author: Osgood, Robert K.
Year: 1988
Title: Pitch cueing in the dynamic seat: An exploratory study
Institution: Armstrong Aerospace Medical Research Laboratory Human Engineering Division (AAMRL/HE)
Date: February 29
Type: Technical Memorandum
Report Number: TM-87-RKO-001
Author's Title and Affiliation: Systems Research Laboratories, Inc., A Division of Arvin Calspan
Number of Pages: 10
Keywords: pitch cueing, dynamic seat, seat-pan, RMS error, ALCOGS, seat position, seat pitch angle
Abstract: Appendix includes a list of notes to trackers, a copy of the questionnaire for subjects in the pitch study, and a pitch study system block diagram.

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Reference Type: Conference Paper
Author: Otto, Deitrich; Irving, Don
Year: 2000
Title: The role of the regulator
Conference Name: Flight Simulation - The Next Decade
Conference Location: London, UK
Publisher: Royal Aeronautical Society (RAeS)
Date: May 10-12
Author's Title and Affiliation: Dietrich Otto: Joint Aviation Authorities, Hoofddorp, The Netherlands
Don Irving: Civil Aviation Authorities, Gatwick, United Kingdom
Number of Pages: 7
Abstract: Where is training on Synthetic Training Devices (STD) heading? Is such training limitless or should the regulator define the limits of STD training acceptability/development. Talking about the regulator this will be the European angle of view, so the Joint Aviation Authorities (JAA) will be the focus. The regulator and all other parties involved are confronted with a vast amount of expectations and resulting commitments, all having a potential influence on rule making. The challenges of higher mobility

on people, technical complexity of equipment and increasingly limited financial and personal resources will have to be addressed, shortcomings identified and subsequently managed.

The goal of mutual recognition of Flight Simulator evaluations within the JAA has been clearly defined - and considerable progress made. Nevertheless there is much ground still to be covered. Mutual recognition has to extend beyond JAA membership and the ideal goal is global harmonization and mutual recognition. FAA/JAA harmonization efforts represent a significant start in this essential process.

The European Union's declaration of competency in the matter of aviation regulation throughout the EU membership will provide a stiff test for the JAA in the content and structure of future Joint Aviation Requirements (JARs), including those for STDs, The establishment of, and transition to, a European Aviation Safety Authority (EASA) will undoubtedly impact on the JAA and care must be taken to ensure that the transition is smooth and that earlier mistakes are not repeated. The European regulator would do well to ensure that future rulemaking follows existing established and well-defined principles to prevent a divergence of the requirements for the EU and non-EU members of the JAA.

Already different Authorities around the world make use of European (JAA) or North American (FAA) civil aviation regulations. Thus if these two standards can be effectively harmonized they could form the basis of a world-wide standard in aviation regulation.

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Reference Type: Conference Paper
Author: Padfield, Gareth D.; Lee, David N.; Bradley, Roy
Year: 2001
Title: How do helicopter pilots know when to stop, turn or pull up? Developing guidelines for vision aids
Conference Name: American Helicopter Society 57th Annual Forum
Conference Location: Washington, D.C.
Date: May 9-11
Number of Pages: 15
Abstract: The title of this paper, posed as a question, reflects the current interest in gaining an improved understanding of visual perception in flight control to inform the development of design guidelines for future pilot vision aids. The paper develops the optical flow theory of visual perception into its most recent incarnation, tau-coupling, where tau is the time to closure to surfaces at current velocity. General tau-theory posits that the closure of any type of gap, using any form of sensory input, is guided by sensing and constantly adjusting the tau of the gap. According to the theory, and contrary to what might be expected, information about the distance to obstacles or the landing surface, for example, and about the speed and deceleration of approach, are not necessary for precise control of landing or stopping. Analysis is presented that supports the importance of tau-coupling in flight control. Results from simulation trials conducted at DERA and at The University of Liverpool demonstrate the considerable power of what we describe as tau-guides, that lead the pilot to adopt a prospective flight control strategy.

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Reference Type: Conference Paper
Author: Page, Ray L.
Year: 2001
Title: Brief history of flight simulation
Conference Name: SimTecT
Conference Location: Canberra, Australia
Publisher: Simulation Industry Association of Australia (SIAA)
Date: May 28-31
Author's Title and Affiliation: R.L. Page and Associates, Former Manager QUANTAS SIMULATION SERVICES, 103 David Road, Lucas Heights NSW 2234
Number of Pages: 7
Keywords: history, Link, Edwin Link, standards
Abstract: Simulation today is a multi-million dollar industry and its application has spread to a vast number of training and analytical requirements. Many of those now involved with this industry have little concept of its origins and the efforts involved to gain recognition and credibility for simulation as a training tool. The use of Simulation for training now dates back over seventy years and as we now enter a new century, it seems appropriate to take a brief look at the history of this Industry.
The origins of the Simulation Industry were generated from the use of flight training devices. This paper briefly outlines the evolution of the flight simulator and the efforts involved to gain recognition for its use, the establishment of standards and the constant demands of matching ever increasing technology. Without doubt the technology available for the simulation task to day and for the future is unbelievable by comparison to that of the past seventy years; however many of the problems such as data, parts and standards which have plagued this industry from its inception, are still evident today. Perhaps, therefore, as we enter this new century, it is appropriate to reflect on our history, so that organizations such as the SIAA can carry on the tradition.
URL: www.siaa.asn.au/get/2395364797.pdf

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Reference Type: Conference Proceedings
Author: Pais, A.R. Valente; Wentink, M.; Mulder, M.; van Paassen, M.M.
Year of Conference: 2007
Title: A study on cueing strategies for curve driving in Desdemona
Conference Name: AIAA Modeling and Simulation Technologies Conference and Exhibit

Conference Location: Hilton Head, SC
Publisher: American Institute of Aeronautics and Astronautics (AIAA)
Date: August 20-23
Electronic Resource Number: AIAA 2007-6473
Author's Title and Affiliation: Pais: PhD student, Control and Simulation Division, Delft University of Technology, P.O. Box 5058, 2600 GB Delft, the Netherlands
Wentink: Researcher, TNO Defense, Security and Safety, P.O. Box 23, 3769 ZG Soesterberg, the Netherlands
Mulder: Associate Professor, Control and Simulation Division, Delft University of Technology, P.O. Box 5058, 2600 GB Delft, the Netherlands
van Paassen: Associate Professor, Control and Simulation Division, Delft University of Technology, P.O. Box 5058, 2600 GB Delft, the Netherlands
Abstract: Desdemona has a fully gimbaled cabin that can, additionally, more vertically plus or minus 1 meter and slide horizontally along an 8 meter track. The track rotates around a central axis, providing a 4 meter long centrifuge arm that can be used to generate sustained accelerations at the cabin. This unique simulator requires specially designed motion filters that can take advantage of the wide motion space. More specifically, the solution of how to combine the traditional onset cues with the centrifuge motion to provide both the high frequency and the sustained accelerations in a realistic manner, is still to be perfected. A study on cueing algorithms for the simulation of curve driving in Desdemona is presented. The results, in terms of angular acceleration and specific forces at the cabin, are discussed and compared to standard hexapod solutions.
Author Address: a.r.valentepais@tudelft.nl; mark.wentink@tno.nl; m.mulder@tudelft.nl m.m.vanpassen@tudelft.nl

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Reference Type: Conference Proceedings
Author: Pandita, R.; Chakraborty, A.; Seiler, P.; Balas, G.
Year of Conference: 2009
Title: Reachability and region of attraction analysis applied to GTM dynamic flight envelope assessment
Conference Name: AIAA Guidance, Navigation, and Control Conference
Conference Location: Chicago, IL
Publisher: American Institute of Aeronautics and Astronautics (AIAA)
Pages: 1-21
Date: Aug. 10-13
Electronic Resource Number: AIAA 2009-6258
Author's Title and Affiliation: Pandita: Graduate Student, Department of Aerospace Engineering and Mechanics, University of Minnesota, Minneapolis, MN
Chakraborty: Graduate Student, Department of Aerospace Engineering and Mechanics, University of Minnesota, Minneapolis, MN
Seiler: Senior Research Associate, Department of Aerospace Engineering and Mechanics, University of Minnesota, Minneapolis, MN
Balas: Professor and Head, Department of Aerospace Engineering and Mechanics, University of Minnesota, Minneapolis, MN
Keywords: loss of control (LOC), dynamic flight envelope, NASA Generic Transport Model (GTM)
Abstract: The objective of the NASA Aviation Safety Program is to improve the safety of current and future aircraft operating in the National Airspace System. Research under this program has focused on vehicle design, construction, operation and maintenance. Reducing aircraft loss of control accidents is critical to increasing aviation safety as it is the largest and most fatal aircraft accident category. Loss of control accidents result in aircraft operation outside the normal flight envelope in regions where aerodynamic data is either poorly characterized or unavailable. Hence it is important to monitor, in real-time, aircraft states and environmental conditions to assess the current state of the aircraft flight envelope. This paper describes the development of algorithms for dynamic flight envelope assessment using reachable set and nonlinear region of attraction techniques and their application to the NASA Generic Transport Model (GTM). The ability to estimate a safe envelope around various operating trim points is demonstrated.

Reference Type: Journal Article
Author: Parasuraman, Raja; Riley, Victor
Year: 1997
Title: Humans and automation: Use, misuse, disuse and abuse
Journal: Human Factors
Volume: 39
Issue: 2
Pages: 230-252
Date: June
Author's Title and Affiliation: Parasuraman: Catholic University of America
Riley: Honeywell Technology Center
Number of Pages: 24
Abstract: This paper addresses theoretical, empirical, and analytical studies pertaining to human use, misuse, disuse, and abuse of automation technology. Use refers to the voluntary activation or disengagement of automation by human operators. Trust, mental workload, and risk can influence automation use, but interaction between factors and large individual differences make prediction of automation use difficult. Misuse refers to over reliance on automation, which can result in failures of monitoring workload, automation reliability and consistency, and the saliency of automation indicators. Disuse, or the neglect of underutilization of automation, is commonly caused by alarms that activate falsely. This often occurs because the base rate of the condition to be detected is not considered in settling the trade-off between false alarms and omissions. Automation abuse, or the automation of functions by designers and implementation by managers without due regard for the consequences for human performance, tends to define the operator's roles as by-products of the automation. Automation abuse can also promote misuse and disuse of automation by human operators. Understanding the factors associated with each of these aspects of human use of automation can lead to improved system design, effective training methods, and judicious policies and procedures involving automation use.

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Reference Type: Magazine Article
Author: Parker, Ian
Year: 2006
Title: Avionics crown Typhoon performance
Magazine: Avionics Magazine
Date: August 1
Keywords: Eurofighter Typhoon, carefree handling, upset recovery training (URT)
Abstract: Electronic systems make Europe's latest fighter a formidable opponent.
URL: http://www.aviationtoday.com/av/categories/military/Avionics-Crown-Typhoon-Performance_1050.html

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Reference Type: Report
Author: Parris, Benton L.; Cook, Anthony M.
Year: 1978
Title: Effects of visual and motion simulation cueing systems on pilot performance during takeoffs with engine failures
City: Moffett Field, CA
Institution: National Aeronautics and Space Administration (NASA), Ames Research Center
Date: December
Type: NASA Technical Paper
Report Number: NASA Technical Paper 1365
Number of Pages: 79
Abstract: Data are presented that show the effects of visual and motion cueing on pilot performance during takeoffs with engine failures. Four groups of USAF pilots flew a simulated KC-135 using four different cueing systems. The most basic of these systems was of the instrument-only type. Visual scene

simulation and/or motion simulation was added to produce the other systems. Learning curves, mean performance, and subjective data are examined. These data show that the addition of visual cueing results in significant improvement in pilot performance, but the combined use of visual and motion cueing results in far better performance.

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Reference Type: Newspaper Article
Reporter: Pasztor, A; Carey, S.
Year: 2009
Title: Commuter airlines: questions of safety
Newspaper: The Wall Street Journal
City: Los Angeles
Volume: 254
Start Page: 129
Pages: A1-A16
Section: Business
Edition: Eastern
Issue Date: December 1
Keywords: simulator training, commuter airlines, safety, pilots' flight experience, Colgan Air
Abstract: The article discusses the safety of commuter airlines operating in the U.S. Of the eight most-recent fatal plane accidents in the U.S., seven involved commuter airlines. Pilots for commuter aircraft often have less training and experience than those for major airlines. Charlie Preusser was hired as a co-pilot at Colgan Air with fewer than 400 flight hours to his credit.
URL: http://online.wsj.com/article/SB125962778738870517.html?mod=dist_smartbrief

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Reference Type: Journal Article
Author: Patankar, Manoj S.; Ma, Jiao
Year: 2006
Title: A review of the current state of aviation safety action programs in maintence organizations
Journal: International Journal of Applied Aviation Studies
Volume: 6
Issue: 2
Pages: 219-234
Number of Pages: 17
Abstract: In maintenance, Aviation Safety Action Programs (ASAPs) were designed to encourage air carrier and repair station employees to report their errors or conditions hazadous to safety of flight voluntarily. Such programs have been operational since 1998. This paper presents the results of a survey of 20 organizations, which was conducted to better understand the current state of the ASAP programs. A rise in the number of ASAP Memorandum of Understanding and the results of this survey indicate that the ASAP programs are gaining support among an increasing number of maintenance organizations across the country. Successful ASAP programs are found to have strong and consistent support from senior management to the extent that they are able to overcome cases that challenge the corporate discipinary policy. The resources required to run such programs at different types of maintenance organizations as well as at the local FAA offices are presented. Comprehensive corrective actions resulting from the investigation of ASAP events are reported at three levels of impact: task-level changes, organization-level changes, and industry-level changes. The authors argue that the effectiveness of ASAP programs in maintenance should be measured by the percentage of actual changes at each level rather than the number of total or sole-source reports. As the number of organizations participating in such programs grows, there will be an increased need to share information about intervention strategies and their effectiveness across participating organizations; therefore, future studies that document a case-by-case analysis of selected ASAP events followed by the development of a common data classification scheme are proposed.

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Reference Type: Newspaper Article
Reporter: Pearl, Daniel
Year: 1994
Title: Flight test: One air crash suggests pilot's mental state may pose safety risk
Newspaper: The Wall Street Journal
City: Chicopee, MA
Pages: 1, A10
Issue Date: May 25
Number of Pages: 2

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Reference Type: Report
Author: Pearson, Gary; Desrochers, Daniel
Year: 2009
Title: Developing airborne speech recognition applications V2
City: Orlando, Florida
Institution: Adacel
Document Number: AP 9950-0016
Pages: 1-25
Date: April 3
Author's Title and Affiliation: Gary Pearson, V.P. Advanced Programs
Daniel Desrochers, Technical Lead, Speech Technologies
Number of Pages: 25

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Reference Type: Conference Proceedings
Author: Perhinschi, Mario G.; Moncayo, Hever; Davis, Jennifer
Year of Conference: 2009
Title: Integrated framework for aircraft sub-system failure detection, identification, and evaluation based on the artificial immune paradigm
Conference Name: AIAA Guidance, Navigation, and Control Conference
Conference Location: Chicago, IL
Publisher: American Institute of Aeronautics and Astronautics (AIAA)
Date: Aug. 10-13
Electronic Resource Number: AIAA-2009-6261
Author's Title and Affiliation: Perhinschi: Assistant Professor, Department of Mechanical and Aerospace Engineering, West Virginia University, Morgantown, WV
Moncayo & Davis: Graduate Students, Department of Mechanical and Aerospace Engineering, West Virginia University, Morgantown, WV
Number of Pages: 17
Keywords: failure detection, failure identification, evaluation, artificial immune system, upset recovery (URT)
Abstract: This paper presents the development of an integrated set of methodologies for the detection, identification, and evaluation of a wide variety of failures of aircraft sub-systems. The detection feature represents the capability to declare that a failure within any of the aircraft sub-systems has occurred. The identification process has two phases. The first phase consists of determining which of the large categories of sub-systems is affected (actuators, sensors, engines, structure, etc.). The outcome of the second phase specifies the failed element. The evaluation of the failure addresses three aspects. The qualitative evaluation attempts to specify the type of the failure. The quantitative evaluation has two components. The direct failure evaluation consists of estimating the magnitude of the failure while the indirect failure evaluation includes the reassessment of the flight envelope and prediction of the limitations and constraints on the performance and handling qualities inflicted by the presence of the failure. Failure detection, identification, and evaluation schemes are included using the bio-immune system metaphor combined with other artificial intelligence techniques such as genetic algorithms, artificial neural networks, and fuzzy logic based adaptive thresholds. The immunity-based fault detection operates in a similar

manner as does the immune system - according to the principle of self-non-self discrimination - when it distinguishes between entities that belong to the organism and entities that do not. This approach addresses directly the complexity and multi-dimensionality of aircraft dynamic response in the context of abnormal conditions and provides the adequate tools to solve the failure detection problem in an integrated and comprehensive manner.

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Reference Type: Book Section
Author: Perrott, D. R.
Year: 1982
Title: Studies in the perception of auditory motion
Editor: Gatehouse, R. W.
Book Title: Localization of Sound: Theory and Applications
City: Groton, CT
Publisher: Amphora Press
Pages: 169-193
Author's Title and Affiliation: Psychoacoustics Laboratory, California State University, Los Angeles, Los Angeles, CA 90032
Number of Pages: 25

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Reference Type: Journal Article
Author: Perry, D. H.; Naish, J. M.
Year: 1964
Title: Flight simulation for research
Journal: The Journal of the Royal Aeronautical Society
Volume: 68
Pages: 645-662
Date: Oct.
Author's Title and Affiliation: D. H. Perry, M. A., Royal Aircraft Establishment, Bedford
J. M. Naish, Ph.D., M.Sc., A.R.C.S., Royal Aircraft Establishment, Farnborough
Number of Pages: 18
Abstract: Some of the uses of ground based flight simulation as a research tool to aid the design of new aircraft and their equipment are described. The function of the simulator is to provide a method for investigating human flying tasks in the laboratory, so that the relationship between the pilot's capabilities and the equipment's characteristics can be systematically studied. The paper is presented in two parts describing recent work on two research simulators at the RAE.
Part I deals with the use of simulation for studying aircraft stability and control characteristics. The equipment used at RAE for this work is described, with particular emphasis on methods of presenting to the pilot a simulated view of the outside world, and for reproducing some of the motion cues which he experiences in flight. Experimental evidence of the importance of these simulation cues when making aircraft control assessments is also presented. Several examples of simulation studies in the control of conventional and VTOL aircraft are given, to illustrate the type of research problems in this field which may be tackled and the techniques involved in solving them.
Part II deals with the development, from a simple flight simulator used in tachistoscopic studies of attitude displays, to more advanced equipment used to study an instrument system for high-speed low-level flight. This involved the concept of information flow in parallel and visually-mediated control loops, for visual flight, by a tele-visual method, and in the assessment of tracking performance, by a method of mean modulus errors; these developments allowing observation of performance of concurrent visual tasks. Flight trials confirmed simulator studies of learning effects, information capacity and instrument to visual transition. The complete scheme of simulation included ground control and autopilot facilities.

Reference Type: Report
Author: Peters, R.A.
Year: 1969
Title: Dynamics of the vestibular system
Institution: NASA
Report Number: NASA CR-1309

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Reference Type: Report
Author: Pfeiffer, M. G.; Horey, J. D.
Year: 1987
Title: Training effectiveness of aviation motion simulation: A review and analysis of the literature
City: Orlando, FL
Institution: Naval Training Systems Center
Date: December
Type: Special Report
Report Number: 87-007
Author's Title and Affiliation: Naval Training Systems Center, Orlando, FL
Keywords: transfer of training, literature review, flight simulators, pilot training, training simulators
Abstract: The literature review included 45 transfer-of-training studies. Only studies providing transfer ratios (TRs) or those that allowed TRs to be estimated were included. Studies were categorized by simulator device features and simulator/aircraft thrust type. Transfer ratios were averaged within similar categories. These averaged transfer ratios were then compared across categories of interest. Conjoint scaling of transfer ratios was performed to adjust for the low number of studies found within some categories and to test for device feature by simulator type interactions. Findings for motion effects were consistent across all types of flight simulators. Accordingly, training with visual plus motion (VISMOT) transferred better than training with visual only (VISNLY) simulation. Similarly, training with motion (MOTION) transferred better than training with no motion (NOMOT) simulation. A separate analysis of transfer effectiveness ratios (TERs) provided results directionally consistent with the above (VISMOT > VISNLY and MOTON > NOMOT).

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Reference Type: Magazine Article
Author: Phillips, Edward H.
Year: 1996
Title: Costs key factor in Part 121 upgrade
Magazine: Aviation Week & Space Technology
Pages: 59-61
Date: May 20
Number of Pages: 3

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Reference Type: Magazine Article
Author: Phillips, Edward H.
Year: 1996
Title: CRM focus of FAA's commuter rule
Magazine: Aviation Week & Space Technology
Pages: 61-64
Date: May 20
Number of Pages: 4
Abstract: About 28 commuter airlines are currently upgrading their pilot training and to get ready for the increased use of flight simulators to meet the FAA's Commuter Rule to come into effect March 27. The more stringent training requirements include:

· Adoption of Line Oriented Flight Training (Loft) that will include more frequent use of simulators to practice Crew Resource Management in normal, abnormal and emergency situations. Simulators have not been widely used because of cost and scheduling difficulties. Flight Safety International, Simuflite and other training providers are currently building advanced simulators of turboprop aircraft.
· CRM training mandatory for pilots, cabin attendants and dispatchers
· Inclusion of Initial Operating Experience of the second in command pilot. SIC must have the same IOE as the PIC.
Aircraft most affected by the new training requirements are Jetstream 31/41, Beechcraft Model 1900 C and D, Bombardier/de Havilland Dash 8 series, Dornier 228, Embraer EMB-120 Brasilia, Fairchild Metro series and the Shorts 330/360 series.
Beechcraft Model 99 and Embraer EMB-110 would also be affected, but are likely to be phased out due to noncompliance with performance requirements. This is true also for the Shorts 330/360 series.

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Reference Type: Magazine Article
Author: Phillips, Edward H.
Year: 1999
Title: NASA targets transport research
Magazine: Aviation Week & Space Technology
Pages: 41
Date: January 4
Number of Pages: 1
Keywords: NASA, Transport Research Facilities
Abstract: Engineers at the NASA/Langley Research Center are modifying a Boeing 757 into a flying laboratory as part of the agency's Transport Research Facilities project designed to support testing of advanced technology concepts.
In November, the aircraft was designated the Airborne Research Integrated Experiments Systems (Aries) and made its first flight on Dec.10 at Langley facilities in Hampton, Va.
Richard Couch, project manager, said the purpose of the Transport Research Facilities (TRF) program is to provide an efficient means to develop and test new technologies formulated by NASA, government and the civil aviation industry. According to Couch, a key objective of TRF is to support a simulation-to-flight process through use of same or similar hardware and software in both ground-based simulation facilities and the airplane.

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Reference Type: Magazine Article
Author: Phillips, E. H.
Year: 1999
Title: United 747 incident spotlights pilot training, safety issues
Magazine: Aviation Week & Space Technology
Pages: 39-40
Date: March 29
Number of Pages: 2
Keywords: upset recovery training (URT), United 747
Abstract: United Airlines' Boeing 747-400 first officer's initial response to an engine failure is fueling concerns about pilot proficiency, current requirements and the airline industry's reliance on simulators to train pilots.

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Reference Type: Magazine Article
Author: Phillips, Edward H.
Year: 2001
Title: Upset training increases across pilot spectrum

Magazine: Aviation Week & Space Technology
Date: November 26
Keywords: upset recovery training (URT)
Abstract: Airline pilot education is changing since a shrinking number of new hires come from military cockpits. In contrast with their civilian-trained counterparts, military pilots brought broader experience in recovering from unusual attitudes and an awareness of the hazardous effects of hypoxia and kinesthetic illusions. These areas are now being covered in the training for prospective commercial pilots. However, air combat training remains specialized with centrifuge-based simulations providing realistic high g-forces for military pilots.

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Reference Type: Magazine Article
Author: Phillips, Edward H.
Year: 2006
Title: Getting upset
Magazine: Aviation Week & Space Technology
Pages: 52
Date: December 4
Type of Article: part of section on Simulation and Training
Number of Pages: 1
Keywords: upset recovery training (URT)
Abstract: New program will teach pilots to recover from attitudes outside the normal flight envelope.
Notes: Part of section on Simulation and Training. All articles in this section include:
Fighting human error (F. Fiorino)
Retooling maintenance lessons (L. A. Tegtmeier)
Getting upset (E. H. Phillips)
A little competition (J. C. Anselmo)
Ready, VLJet, go (F. Fiorino)

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Reference Type: Conference Paper
Author: Pinet, Jean
Year: 1970
Title: Cockpit environment
Conference Name: Simulation; Flight Mechanics Panel
Conference Location: Ames Research Center, Moffett Field, CA
Publisher: Advisory Group for Aerospace Research and Development (AGARD)
Date: March
Author's Title and Affiliation: S.N.I.A.S., Test Pilot assigned to Concorde, Usines de Toulouse, B.P, 1503, 31, Toulouse, France
Number of Pages: 12
Keywords: cockpit, visual, aural, visual display
Notes: Lead discussion by D. K. Mendela and Dr. Dora Dougherty Strother. Also includes an open discussion.

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Reference Type: Report
Author: Planning Systems International (PSI)
Year: 1984
Title: Airplane simulator use in airman certification: Special project team, facilities and services
City: Falls Church, VA
Institution: Planning Systems International
Pages: 1-24

Date: January 9
Type: Technical and Management Proposal
Report Number: DOT/FHA Regulatory Resume No. VS-83-105-R

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Reference Type: Conference Proceedings
Author: Pool, D.M.; Chu, Q.P.; van Paassen, M.M.; Mulder, M.
Year of Conference: 2008
Title: Optimal reconstruction of flight simulator motion cues using extended kalman filtering
Conference Name: AIAA Modeling and Simulation Technologies Conference
Conference Location: Honolulu, HI
Publisher: American Institute of Aeronautics and Astronautics (AIAA)
Electronic Resource Number: AIAA 2008-6539
Author's Title and Affiliation: Delft University of Technology, Delft, The Netherlands
Abstract: For evaluation of simulator motion and motion platform dynamics, the motion cues generated in flight simulators need to be measured. For the SIMONA Research Simulator at Delft University of Technology, the availability of redundant kinematic motion sensors – i.e. an Inertial Measurement Unit and sensors that measure the lengths of the motion system actuators – was expected to allow for optimal estimation of the flight simulator motion state using an Extended Kalman Filter. As a starting point, this sensor fusion problem was evaluated for only symmetrical simulator motion, omitting the additional asymmetrical motion states. The highly nonlinear relation between the extension of the motion base actuators and simulator position and orientation was found to require the application of an Iterative Extended Kalman Filter to ensure adequate filter convergence. Using this iterative filter, optimal estimates of the symmetrical simulator state and the IMU biases could be obtained from the two sets of redundant kinematic observations.
Author Address: Control and Simulation Division, Delft University of Technology, P.O. Box 5058, 2600GB Delft, The Netherlands
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m.m.vanpaassen@tudelft.nl
m.mulder@tudelft.nl

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Reference Type: Conference Proceedings
Author: Pool, D.M.; Mulder, M.; van Paassen, M.M.
Year of Conference: 2007
Title: A review of the Hosman and Van der Vaart tracking experiment
Conference Name: AIAA Modeling and Simulation Technologies Conference and Exhibit
Conference Location: Hilton Head, SC
Publisher: American Institute of Aeronautics and Astronautics (AIAA)
Date: August 20-23
Electronic Resource Number: AIAA 2007-6896
Author's Title and Affiliation: Pool: PhD student
Mulder and van Paassen: Associate Professor
Control and Simulation Division, Faculty of Aerospace Engineering, Delft University of Technology, P.O. Box 5058, 2600 GB Delft, the Netherlands
Abstract: One of the first large research projects on human control behavior performed at Delft University of Technology is the work of Hosman and Van der Vaart. In their tracking experiment, Hosman and Van der Vaart investigated the influence of visual and vestibular motion cues on human control behavior in a situation similar to manual control of an aircraft. In these compensatory tracking tasks, subjects were asked to follow or counteract a signal presented on a central (foveal) display. The changes in performance and control behavior were investigated for the addition of peripheral visual and vestibular motion cues.

Both disturbance and target following tasks were performed with exactly the same forcing function signal realization. This resulted in a target following and disturbance task which were both thought to be representative for manual control in actual flight, but yielded a significant difference in task difficulty between both types of task. Because of this discrepancy in task difficulty, it is unsure to what extent the differences between the two groups of tracking task observed by Hosman and Van der Vaart actually result from their inherent differences, or are caused by the different levels of task difficulty.
This paper describes the results of a recent experiment, highly similar to the tracking experiment of Hosman and Van der Vaart, that was performed in the SIMONA Research Simulator at Delft University of Technology. The goal of the experiment was to measure the effect of different visual and vestibular motion cues on control behavior in compensatory target following and disturbance tasks of equal difficulty, thereby allowing for clear comparison of use of motion cues in both types of tasks. The results of this experiment indicate that the main trends in tracking performance and control behavior reported by Hosman and Van der Vaart for their target following and disturbance tasks can still be seen as representative for both types of classical compensatory tracking task.

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Reference Type: Conference Proceedings
Author: Pool, D. M.; Zaal, P. M. T.; van Paassen, M. M.; Mulder, M.
Year of Conference: 2009
Title: Effects of heave washout settings in aircraft pitch disturbance rejection
Conference Name: AIAA Modeling and Simulation Technologies Conference
Conference Location: Chicago, IL
Publisher: American Institute of Aeronautics and Astronautics (AIAA)
Pages: 1-20
Date: Aug. 10-13
Electronic Resource Number: AIAA-2009-6241
Author's Title and Affiliation: Pool & Zaal: PhD Candidates, Control and Simulation Division, Faculty of Aerospace Engineering, Delft University of Technology, Delft, The Netherlands
van Paassen: Associate Professor, Control and Simulation Division, Faculty of Aerospace Engineering, Delft University of Technology, Delft, The Netherlands
Mulder: Professor, Control and Simulation Division, Faculty of Aerospace Engineering, Delft University of Technology, Delft, The Netherlands
Number of Pages: 20
Keywords: heave, washout, motion, simulator, pitch, attitude
Abstract: In most moving-base flight simulators, the simulated aircraft motion needs to be filtered with motion washout filters to keep the simulator within its limited motion envelope. Translational motion in particular requires filtering, as the low frequency components of the vehicle motion tend to quickly drive simulators toward their motion bounds. Commonly, linear washout filters are therefore used to attenuate the simulated motion in magnitude and in phase. It is found in many studies that the settings of these washout filters affect pilot performance and control behavior. In most of these studies, no comparison to a case with one-to-one motion cues is performed, as a result of the limited motion envelope of the used simulators. In the current study, an experiment was performed in the SIMONA Research Simulator at Delft University of Technology to investigate the effects of heave washout settings on pilot performance and control behavior in a pitch attitude control task. In addition to rotational pitch motion, heave accelerations at the pilot station that result directly from aircraft pitch were evaluated. This heave motion component could be supplied one-to-one in the simulator due to the modest size of the aircraft model, a Cessna Citation I business jet. The experiment revealed that pilot performance and control activity both increased significantly with increasing heave motion fidelity. An analysis of pilot control behavior using pilot models indicated that the enhanced performance was caused by an increase in the magnitude with which pilots responded to visual and physical motion stimuli and a decrease in the amount of visual lead that was generated by the pilots.

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Reference Type: Conference Proceedings
Author: Pool, D. M.; Zaal, P. M. T.; van Paassen, M. M.; Mulder, M.
Year of Conference: 2009
Title: Identification of roll attitude control behavior during turn maneuvers
Conference Name: AIAA Modeling and Simulation Technologies Conference
Conference Location: Chicago, IL
Publisher: American Institute of Aeronautics and Astronautics (AIAA)
Pages: 1-19
Date: Aug. 10-13
Electronic Resource Number: AIAA-2009-6029
Author's Title and Affiliation: Pool & Zaal: PhD Candidates, Control and Simulation Division, Faculty of Aerospace Engineering, Delft University of Technology, Delft, The Netherlands
van Paassen: Associate Professor, Control and Simulation Division, Faculty of Aerospace Engineering, Delft University of Technology, Delft, The Netherlands
Mulder: Professor, Control and Simulation Division, Faculty of Aerospace Engineering, Delft University of Technology, Delft, The Netherlands
Number of Pages: 19
Keywords: roll attitude, tracking, multimodal pilot model, identification
Abstract: For an aircraft roll attitude tracking task, the consequences of using target signals that consist of multiple ramp-like changes in target roll attitude for the identification of multimodal pilot models were considered. Such target signals are found to yield a control task that is similar to flying a series of commanded turn maneuvers. Previous experiments, however, showed some negative implications for the identifiability of pilot control behavior. Here, the effects of ramp signal design are investigated by considering two values for ramp steepness, that is, 1 deg/s and 3 deg/s. Additional experimental conditions evaluated the use of a compensatory or a pursuit display, and of the presence of an additional multisine target signal, on pilot model identification. Ramp signal design and the different visual displays considered in the experiment did not show significant effects on the identifiability of multimodal pilot models. Superimposing a low-power multisine target signal on top of a ramp target signal is found to yield a markedly more consistent and stable pilot model identification problem than is obtained for pure ramp-following tasks. Both ramp signal design and visual display format were found to affect the adopted control strategy, as subjects clearly controlled with a lower gain during tracking of the 1 deg/s ramps and when a pursuit display was used.

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Reference Type: Newspaper Article
Reporter: Pope, S.
Year: 1997
Title: Flight simulators: New corporate and regional sims deliver virtual realism to today's business pilots
Newspaper: Aviation International News
City: Midland, NJ
Pages: 22-28
Issue Date: February 1

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Reference Type: Electronic Article
Author: Popular Mechanics
Year: 2005
Title: What went wrong: The crash of flight 587
Periodical Title: Popular Mechanics
Issue: January
Keywords: American Airlines flight 587, upset recovery training (URT)
Abstract: After a three-year investigation, the official report finally answers lingering questions.
URL: http://www.popularmechanics.com/technology/industry/1303226.html
Access Date: October 16, 2006

Reference Type: Journal Article
Author: Pouliot, Nicolas A.; Gosselin, Clément M.; Nahon, Meyer A.
Year: 1998
Title: Motion simulation capabilities of three-degree-of-freedom flight simulators
Journal: Journal of Aircraft
Volume: 35
Issue: 1
Pages: 9-17
Date: February
Alternate Journal: 1996 AIAA Flight Simulation Technologies Conference Proceedings (Paper 96-3474)
Author's Title and Affiliation: Pouliot: Graduate Student, Département de Génie Méchanique, Université Laval, Québec G1K 7P4, Canada
Gosselin: Professor, Département de Génie Méchanique, Université Laval, Québec G1K 7P4, Canada
Nahon: Associate Professor, Department of Mechanical Engineering, University of Victoria, Victoria, British Columbia V8W 3P6, Canada
Abstract: This paper presents the results of a study aimed at determining the simulation realism that might be achieved using reduced-degree-of-freedom flight simulator motion bases. More specifically, the quality of motion produced by two different three-degree-of-freedom platforms was compared to that produced by a conventional six-degree-of-freedom Stewart platform. The three-degree-of-freedom motion bases investigated were a spherical mechanism allowing only rotational motions, as well as a motion base capable of heave, pitch, and roll motions. To compare the different motion bases, three characteristic maneuvers were simulated using a nonlinear model of a Boeing 747. The aircraft motions were then simulated on nine different combinations of virtual motion platforms and motion base drive algorithms. The motion cues (specific forces and angular velocities) produced in this manner were then graphically compared. The analysis revealed that, in most cases, a three-degree-of-freedom simulator is capable of producing motion simulation quality comparable to that produced by a six-degree-of-freedom Stewart platform. Analysis of the motion sensations, as produced by a vestibular model, revealed nearly the same results as the motion analysis.
Author Address: pouliot@gmc.ulaval.ca
gosselin@gmc.ulaval.ca
mnahon@me.uvic.ca

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Reference Type: Conference Paper
Author: Pouliot, Nicolas A; Nahon, Meyer A; Gosselin, Clement A
Year: 1996
Title: Analysis and comparison of the motion simulation capabilities of third-degree-of-freedom flight simulators
Conference Name: AIAA Flight Simulation Technologies Conference
Conference Location: San Diego, CA
Publisher: American Institute of Aeronautics and Astronautics (AIAA)
Date: July 29-31
Electronic Resource Number: Technical Papers (A96-35001 09-01)
Author's Title and Affiliation: Nicolas A. Pouliot and Clement M. Gosselin: Departement de Genie Mécanique, University of Laval, Quebec, Qc, Canada
Meyer A. Nahon: Department of Mechanical Engineering, University of Victoria, Victoria, B.C., Canada
Number of Pages: 11
Abstract: We present results of a preliminary study aimed at determining the simulation realism which could be achieved using reduced degree of freedom (DOF) flight simulator motion bases. The quality of motion produced by two different 3-DOF platforms was compared to that produced by a standard 6-DOF Stewart platform. The 3-DOF motion bases investigated include a spherical mechanism which allows only rotational motions, as well as a motion base capable of heave, pitch and roll motions. To compare the different motion bases, four characteristic maneuvers were simulated using a nonlinear model of a Boeing 747. The aircraft motions were then simulated on nine different combinations of virtual motion platforms and motion base drive algorithms. The motion cues (specific forces and angular velocities) produced in

this manner were then graphically compared. The analysis revealed that, in most cases, a 3-DOF simulator is capable of producing motion simulation quality comparable to that produced by a 6-DOF Stewart platform.

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Reference Type: Conference Proceedings
Author: Praamstra, F.J.; Zaal, P.M.T.; Pool, D.M.; Ellerbroek, J.; Mulder, M.; Van Paassen, M.M.
Year of Conference: 2008
Title: Function of attitude perception in human control behavior in target tracking tasks
Conference Name: AIAA Modeling and Simulation Technologies Conference
Conference Location: Honolulu, HI
Publisher: American Institute of Aeronautics and Astronautics (AIAA)
Electronic Resource Number: AIAA 2008-6845
Author's Title and Affiliation: Control and Simulation Division, Faculty of Aerospace Studies, Delft University of Technology, Delft, The Netherlands
Abstract: In attitude target tracking tasks with a compensatory visual display, pilot tracking performance is found to increase significantly when rotational motion cues are available. The pilot utilizes the system attitude information to reduce the order of the controlled system, yielding an easier equivalent system which is controlled by the visual response. A system-theoretical sensitivity study of the multi-channel pilot-vehicle system observed in compensatory target tasks, revealed that optimal performance is attained when the required lead is generated with the motion perception channel, causing the visual lead time constant to reduce and the visual gain to increase. The interaction of visual and vestibular perception channels is such that the total open-loop response function approximates a single-integrator system.
To evaluate the function of system attitude perception in human control behavior in compensatory target-following tasks, a pitch tracking experiment, in which the availability and presentation of attitude information was varied systematically, was conducted in the SIMONA Research Simulator. Analysis of the performance and control behavior of seven subjects, revealed that human pilots are able to perceive and utilize system attitude information, presented both through visual and vestibular cues, to improve tracking performance considerably. Perception capabilities of the vestibular system were found to be superior to those of the visual system, which resulted in significantly better performance for target tracking tasks with motion.
Author Address: Delft University of Technology, P.O. Box 5058, 2600 GB Delft, The Netherlands

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Reference Type: Journal Article
Author: Previc, Fred H.; Kenyon, Robert V.; Boer, Erwin R.; Johnson, Beverly H.
Year: 1993
Title: The effects of background visual roll stimulation on postural and manual control and self-motion perception
Journal: Perception and Psychophysics
Volume: 54
Issue: 1
Pages: 93-107
Author's Title and Affiliation: Previc: Armstrong Laboratory, Brooks Air Force, TX
Kenyon, Boer: University of Illinois, Chicago, IL
Johnson: KRUG International, San Antonio, TX
Number of Pages: 15
Abstract: The effects of background visual roll stimulation on postural control, manual control, and self-motion perception were investigated in this study. In the main experiment, 8 subjects were exposed to wide field-of-view background scenes that were tilted and static, continuously rotating, or sinusoidally rotating at frequencies between 0.03 and 0.50 Hz, as well as a baseline condition. The subjects performed either a postural control task (maintain an upright stance) or a manual control task (keep an unstable central display horizontally level). Root-mean square (RMS) error in both the postural and manual control tasks was low in the static tilt condition and extremely high in response to continuous

rotation. Although the phases of the postural and manual responses were highly similar, the power and RMS error generated by the sinusoidal visual background stimulation peaked at a lower frequency in the postural task. Vection ratings recorded at the end of the postural and manual trials somewhat paralleled the frequency tuning differences between tasks, which a subsequent experiment showed to be the result of the differential motion of the central display rather than the differential positioning of the subject. In general, these results show that the dynamic characteristics of visual orientation systems vary according to the specific motor and/or perceptual system investigated.

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Reference Type: Report
Author: Prince, Carolyn
Year: 1998
Title: Guidelines for situation awareness training
Institution: NAWCTSD/UCF/FAA, Partnership for Aviation Team Training
Type: Training Guide
Author's Title and Affiliation: Ph.D., NAWCTSD/FAA/UCF Partnership for Aviation Team Training
Number of Pages: 75

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Reference Type: Journal Article
Author: Proctor, Michael D.; Bauer, Maria; Lucario, Thomas
Year: 2007
Title: Helicopter flight training through serious aviation gaming
Journal: The Journal of Defense Modeling and Simulation: Applications, Methodology, Technology
Volume: 4
Issue: 3
Pages: 277-294
Electronic Resource Number: 10.1177/154851290700400305
Number of Pages: 18
Keywords: aviation, training, personal computers
Abstract: The notion of Serious Games dates to at least 1970. More recently leaders also identified gaming technology as a possible disruptive technology. If off-the-shelf PC-based aviation games and the vast library of related civilian developed databases and models can be leveraged for serious training use, then existing flight training paradigms from familiarization training to mission rehearsal might be disrupted and provide the military financial, safety, quality, and time benefits for even less cost. This research investigates the contribution that an off-the-shelf, PC-based, aviation game makes to learning using three inexpensive interface configurations. The simulator performance improvement methodology is used to measure the contribution. The research considers interface usability, model fidelity, and simulation sufficiency for task learning. The research also investigates the difference in performance of pilots with and without turbulence with increased load in these configurations. The specific task chosen for research was combat search and rescue with turbulent weather conditions. All forty-five participants in the research were in training to become licensed helicopter pilots. Results of their subjective assessments are also included.

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Reference Type: Report
Author: Prophet, Wallace W.; Boyd, H. Alton
Year: 1970
Title: Device-task fidelity and transfer of training: Aircraft cockpit procedures training
City: Fort Rucker, Alabama
Institution: Human Resources Research Organization
Date: July
Type: Technical Report
Report Number: 70-10
Number of Pages: 45

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Reference Type: Report
Author: Prophet, W. W.; Caro, P. W.; Hall, E. R.
Year: 1972
Title: Some current issues in the design of flight training devices
Institution: Human Resources Research Organization (HumRRO)
Pages: 133-140
Date: March
Type: Professional Paper
Report Number: HumRRO-PP-5-72
Author's Title and Affiliation: Human Resources Research Organization (HumRRO)
Number of Pages: 8
Abstract: The value of the system engineering approach to training program development has become fairly well recognized. Not so well recognized, however, are the implications of the approach for training equipment design. Systems engineering of training focuses on the student and emphasizes the job for which training is to be given. All decisions concerning training should be made in favor of the student. The essential question is always, "How can he best be trained to perform the job he will be required to do?"
In selecting or designing training equipment, of whatever order of complexity, careful attention should be given to what the student needs to know and be able to do to perform successfully on the operational job. Care should be taken to ensure that equipment provides the necessary information context and/or allows for the creation of appropriate job-relevant conditions for performance practice. Too often, though, emphasis is placed solely on duplication of the operational system. The result may be an excellent simulation, but a less-than-optimal trainer. Attention should also be given to the inclusion within design of features whose sole function is to facilitate the student's acquisition of knowledge and skill, features based on the laws and principles which govern human learning and retention. These features may represent deliberate departures from the real-world or operational system model underlying the usual high-fidelity simulation. The learning and performance characteristics of the device user, the student, must be paramount if simulators or trainers are to be maximally effective learning systems.
This paper develops the rationale described and examines several considerations relevant to training equipment design from the systems engineering standpoint. Suggested design features based on particular student learning needs and on student learning characteristics are presented. Training equipment design features for particular categories of training objectives and for levels of training (e.g., initial training of aviators vs. transition training) are considered. Also discussed is the criticality of the synthetic training program with respect to the total training engineering process.

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Reference Type: Conference Paper
Author: Prothero, Jerrold; Draper, Mark H.; Furness, Thomas A.; Parker, Donald E.; Wells, Maxwell J.
Year: 1997
Title: Do visual background manipulations reduce simulator sickness?
Conference Name: International Workshop on Motion Sickness
Conference Location: Marabella, Spain
Date: May 26-28

Author's Title and Affiliation: Human Interface Technology Laboratory, University of Washington, Seattle, WA USA 98105
Number of Pages: 3
Abstract: (first paragraph) This paper puts forward the "Rest Frame Hypothesis," which addresses how the nervous system performs spatial position, orientation and motion judgments. The hypothesis is quite simple and is implicit in a great deal of existing literature. By making the hypothesis explicit, we suggest that several literatures can be linked in a simple and elegant way. These include literatures on motion sickness; on sense of presence in virtual environments; and six classes of visual illusions. The benefits include: the ability to borrow between these literatures; a predicted technique for reducing simulator sickness; Class A ("objective") measures for presence; and a simple display manipulation for increasing presence at a constant field-of-view.

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Reference Type: Conference Paper
Author: Pugh, John; Wood, Simon J.
Year: 2000
Title: Flight crew training needs for the future
Conference Name: Flight Simulation - The Next Decade
Conference Location: London, UK
Publisher: Royal Aeronautical Society (RAeS)
Date: May 10-12
Author's Title and Affiliation: Captains, Virgin Atlantic Airways, Crawley, England
Number of Pages: 6
Abstract: The current JAA training regulations present an imbalance of emphasis of training requirements versus modern air transport operations and identifies causes of aircraft accidents and incidents. Compared with the 1960's, today's air transport carriers operate in areas of high aircraft density, in worse weather and in higher frequency to areas of inhospitable terrain. Advances in technology have resulted in more reliable aircraft systems that fail, mechanically, less often but these advances have introduced problems in man-machine interface and the management of complex computer controlled systems.
Training and checking for events covering mechanical failures are stipulated in detail whereas environmental factors and system management failures are only stipulated within the context of a broad collection of categories from which the operator may choose a minimum number at random. This creates an imbalance in emphasis within the training regulations. The task and operation of modern air transport has grown, training requirements have not grown in pace.

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Reference Type: Report
Author: Puig, Joseph A.; Harris, William T.; Ricard, Gilbert L.
Year: 1978
Title: Motion in flight simulation: An annotated bibliography
City: Orlando, FL
Institution: Naval Training Equipment Center
Date: July
Type: Technical Report
Report Number: NAVTRAEQUIPCEN IH-298
Author's Title and Affiliation: Puig, Ricard: Human Factors Laboratory
Harris: Advanced Simulation Concepts Laboratory
Number of Pages: 159
Keywords: motion simulation, simulator sickness, effects of motion, flight training, motion drive algorithms, motion simulation requirements, motion simulators, cost-effectiveness
Abstract: In support of Project 7744 - Motion Drive Signals for Flight Simulators, a review of the literature concerning motion simulation was conducted. Abstracts were included for 682 references. A primary objective of this review was to compare data from the various studies to identify general trends on the

effects of motion on performance and training. The publications were listed alphabetically by author, chronologically, and also grouped into eight major categories as follows: reviews and bibliographies; equipment descriptions; requirements; algorithms and drive techniques; effects of motion; evaluation; vertical motion, and cost effectiveness.

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Reference Type: Magazine Article
Author: Quantum3D
Year: 2003
Title: Scalable, COTS IG solutions
Magazine: Training & Simulation Journal
Date: May 22
Type of Article: advertisement
Number of Pages: 1

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Reference Type: Report
Author: Ragland, Stuart; Chambers, Randall M.; Crosbie, Richard J.; Hitchcock, Lloyd
Year: 1964
Title: Simulations and the effects of severe turbulence on jet airline pilots.
City: Johnsville
Institution: U.S. Naval Air Development Center
Pages: 1-45
Date: 13 Aug
Report Number: 1
Author's Title and Affiliation: Stuart Ragland, Jr., CDR, MC, USN
Randall M Chambers, Ph.D.
Richard J. Crosbie, M.A.
Lloyd Hitchcock, Jr., Ph.D.
Number of Pages: 45

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Reference Type: Magazine Article
Author: Ramsey, James W.
Year: 1997
Title: GPS spells efficiency for regional carriers
Magazine: Avionics Magazine
Pages: 24-30
Date: September
Number of Pages: 7
Keywords: ACA
Abstract: United Express carrier Atlantic Coast Airlines is among regional airlines benefiting from GPS-based flight management systems

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Reference Type: Journal Article
Author: Randle, Robert J.; Sinacori, John
Year: 1980
Title: Visual space perception
Pages: 257-258
Number of Pages: 2
Keywords: visual space perception, simulation fidelity, perceptual fidelity, functional fidelity
Abstract: (first paragraph) Computer-generated scenes are presented in perspective view and optically localized at infinity (or at least at a great and constant distance) on a vertically projected surface in a two-dimensional depiction of three-dimensional space; this provides a visual environment that is at best illusory. Roscoe has referred to it as "The apparent realism of the illusions created." This deception has not been too disruptive for the great wealth of training that has been and is being accomplished in fixed-wing simulators, but it may well be a source of problems in rotary-wing training, particularly since the need for these pilots to make accurate size, distance, and rate judgments is so crucial to their maneuvering versatility and safe flight. Frequently mentioned complaints with simulators of rotary-wing aircraft are the lack of field of view and inadequate textural cues. It is to be noted that these complaints may really mask more fundamental inadequacies caused by the way we currently present extracockpit scenes.

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Reference Type: Journal Article
Author: Rankin, William B.; Cokley, John
Year: 2006
Title: Enhancing life in the hyper-surveillance mini-world of a space station: The role of situation awareness, communication, and reality TV in the life of astronauts
Journal: International Journal of Applied Aviation Studies

Volume: 6
Issue: 2
Pages: 283-298
Number of Pages: 16
Abstract: This is the third article of a series entitled Astronauts as Audiences. In this article, we investigate the roles that situation awareness (SA), communications, and reality TV (including media communications) might have on the lives of astronauts in remote space communities. We examined primary data about astronauts' living and working environments, applicable theories of SA, communications, and reality TV (including media communications). We then surmised that the collective application of these roles might be a means of enhancing the lives of astronauts in remote space communities.

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Reference Type: Electronic Article
Author: Ransbury, Paul
Year: 2008
Title: What's the big deal about angle of attack?
Periodical Title: APS Emergency Maneuver Training
Author's Title and Affiliation: President, APS Emergency Maneuver Training
Part 141 Chief Flight Instructor
Master CFI-Aerobatic/CFI/CFII/MEI/AGI
Airbus A320 Pilot, F/A-18 Hornet Fighter Pilot
Cirrus Standardized Instructor
Fighter Weapons Instructor
ICAS Certified Air Show Performer
Number of Pages: 16
Keywords: upset recovery training (URT)
Abstract: How exactly do you put your finger on the single most important aerodynamic component or practice related to upset recovery training? That's a tough question and, quite honestly, the answer varies depending upon the situation being addressed. As opposed to picking "one" aerodynamic component as "the" critical factor in upset recoveries, a thorough discussion of recovery techniques must focus on the order in which control loss issues are addressed for a generalized recovery to be effective in a wide variety of circumstances. In Figure 1, the All-Attitude Upset Recovery checklist developed by APS Emergency Maneuver Training addresses the mental processes and order in which a loss of control situation should be managed by the pilot.
URL: http://www.apstraining.com/Docs/Angle-of-Attack-APS-Training.pdf
Access Date: 3/24/08

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Reference Type: Conference Proceedings
Author: Rantanen, Esa M.; Talleur, Donald A.
Year of Conference: 2005
Title: Incremental transfer and cost effectiveness of ground-based flight trainers in university aviation programs
Conference Name: Human Factors and Ergonomics Society 49th Annual Meeting
Publisher: Human Factors and Ergonomics Society (HFES)
Author's Title and Affiliation: Institute of Aviation, University of Illinois at Urbana-Champaign, Savoy, Illinois
Abstract: Use of ground-based flight training devices in flight training is attractive for several reasons. In addition to undeniable safety aspects and immunity to weather, ground trainers also offer benefits in terms of training effectiveness, typically measured by the time or number of trials saved over training exclusively in an airplane. A review of 19 studies from the past 56 years that have investigated transfer of training effectiveness from ground trainers to airplane revealed, however, that unambiguous conclusions about the best use of these devices are difficult to discern. The reason for the lack of valid data and

widely varied results are the large number of intervening variables present in flight training as well as the difficulty of conducting sound research on this topic.
URL: http://www.humanfactors.uiuc.edu/Reports&PapersPDFs/humfac05/rantal.pdf

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Reference Type: Conference Proceedings
Author: Ray, Paul A.
Year of Conference: 1996
Title: Quality flight simulation cueing - Why?
Conference Name: AIAA Flight Simulation Technologies Conference
Conference Location: San Diego, CA
Publisher: American Institute of Aeronautics and Astronautics (AIAA)
Date: July 29-31
Electronic Resource Number: AIAA-1996-3488
Author's Title and Affiliation: Manager, Federal Aviation Administration, National Simulator Program
Number of Pages: 11
Abstract: The issue of flight simulation cueing is the subject of many proposals from highly motivated individuals and organizations. Such proposals take on many forms. Some would advocate the removal of motion from all simulation requirements. Others would propose that "PC" based representations of systems are sufficient to qualify as a Flight Training Device for a specific airplane.
This paper addresses the causes for the need for accurate cueing in simulation and the potential impact of less than faithful replication of those cues. Specific areas addressed include motion, visual and tactile feel cueing requirements. Examples of the results of less than accurate cueing are provided. Experiences of simulation within the medical community are reviewed and addressed regarding the impact of less than realistic simulation cueing.

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Reference Type: Conference Paper
Author: Ray, Paul A.
Year: 1999
Title: Flight simulator qualification
Conference Name: The Fifteenth Annual Flight and Ground Vehicle Simulation Update
Conference Location: State University of New York at Binghamton
Date: January 11-15
Author's Title and Affiliation: Manager, Federal Aviation Administration, National Simulator Program
Number of Pages: 21

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Reference Type: Conference Paper
Author: Ray, Paul A.
Year: 2000
Title: Is today's flight simulator prepared for tomorrow's requirements?
Conference Name: Flight Simulation - The Next Decade
Conference Location: London, UK
Publisher: Royal Aeronautical Society (RAeS)
Date: May 10-12
Author's Title and Affiliation: Manager, National Simulator Program, Federal Aviation Administration, Atlanta, GA
Number of Pages: 8
Abstract: The role of flight simulation in today and tomorrow's training environment clearly tests the capacity of yesterday's flight simulators. The aviation industry (manufacturer, user, and regulator) clearly desires an increasing reliance upon flight simulation for total training and testing. Due, in large part, to the

success of yesterday's flight simulators, it is highly likely that flight simulators will become the mandated vehicle for training and testing, not simply a cost effective alternative for those able to afford its benefits. As training centers and airlines address the potential use of flight simulators for limited unusual attitude training, prevention of controlled flight into terrain and training in areas unsafe to perform in actual flight, regulatory authorities are, in all likelihood, going to increase flight simulator fidelity requirements.
This paper addresses fidelity issues that, in some cases are clearly lacking in some of today's flight simulators and previously assumed to be accurately presented. Should those deficiencies be corrected? Should "grandfather rights" prevail? To what extent should existing flight simulators be "grandfathered"? These issues, as well as other fidelity issues are addressed. Recommendations are offered for correcting omissions and/or updating current flight simulation. Other recommendations, including FAA and JAA resolution to update international sound, visual and motion standards are also discussed.

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Reference Type: Journal Article
Author: Reason, J. T.
Year: 1970
Title: Motion sickness: A special case of sensory rearrangement
Journal: Advancement of Science
Volume: 26
Issue: 130
Pages: 386-393
Author's Title and Affiliation: BSC/Ph.D., University of Manchester, Department of Psychology
Number of Pages: 8

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Reference Type: Journal Article
Author: Reason, J. T.
Year: 1978
Title: Motion sickness adaptation: A neural mismatch model
Journal: Journal of the Royal Society of Medicine
Volume: 71
Issue: November
Pages: 819-829
Author's Title and Affiliation: BSC/Ph.D., University of Manchester, Department of Psychology
Abstract: (Introduction) In almost all susceptible individuals, continued exposure to a provocative motion stimulus leads to the diminution and eventual disappearance of established motion sickness reactions. This reduction in symptomatology takes place without any change in the nauseogenic stimulus; indeed, it is the absence of such variation that promotes its occurrence. These observations are clearly of considerable importance for elucidating the factors involved in the aetiology of motion sickness, as they demonstrate the existence of processes within the individual that are capable of counteracting the disturbing properties of the imposed motion without recourse to any external agency. It follows, therefore, that a better appreciation of how this *vis medicatrix naturae* operates must bring us closer to understanding how these curious and inappropriate reactions become established in the first place, since adaptation and provocation appear to be two sides of the same coin.
The theoretical arguments presented here are directed toward answering two basic questions concerning the aetiology of motion sickness. First, what is the essential nature of the provocative stimulus? How do we explain the occurrence of motion sickness over such a wide range of apparently diverse circumstances? What, for example, do the conditions that elicit space sickness have in common with those that induce seasickness, airsickness, car sickness, camel sickness, swing sickness, simulator sickness, and so on? This question is dealt with briefly as a necessary prelude to the main concern of this paper, namely: what are the mechanisms underlying the acquisition of protective adaptation, and of its sequel *mal de débarquement*? The principle research findings relating to the effects and after-effects of protective adaptation are summarized, and a neural mismatch model is described which attempts to account for these data.

Reference Type: Report
Author: Rediess, Harman A.
Year: 2002
Title: FAA assessment of anti-terrorist devices
Author's Title and Affiliation: PhD, Director, Office of Aviation Research, Federal Aviation Administration
Keywords: automatic flight control, envelope protection, refuse-to-crash, upset recovery training (URT)
Abstract: An assessment of automatic or remote control of distressed commercial transports as a means of mitigating a hijacked transport being used as a weapon.
URL: http://www.saferplane.com/faaassessment.htm
Access Date: August 25, 2008

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Reference Type: Journal Article
Author: Regan, W. C.; Price, K. R.
Year: 1994
Title: The frequency of occurrence and severity of side-effects of immersion virtual reality
Journal: Aviation, Space, and Environmental Medicine (ASEM)
Volume: 1994
Issue: 65
Pages: 527-530
Author's Title and Affiliation: Regan: B.Sc.
Price: B.A.
Number of Pages: 4
Abstract: Virtual reality (VR) has become increasingly well-known over the last few years. However, little is known about the side-effects of prolonged immersion in VR. This study set out to investigate the frequency of occurrence and severity of side-effects of using an immersion VR system. Out of 146 subjects, 61% reported symptoms of malaise at some point during a 20-min immersion and 10-min post-immersion period. These ranged from symptoms such as dizziness, stomach awareness, headaches, eyestrain and lightheadedness to severe nausea. These symptoms caused 5% of the subjects to withdraw from the experiment before completing their 20-min immersion period. Further research needs to be conducted that attempts to identify those factors that play a causative role in the side-effects of the VR system, and that looks for methods of reducing these side-effects.

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Reference Type: White Paper
Author: Regional Airline Association (RAA)
Year: 2008
Title: Government research indicated simulator motion adds training complexity - RAA recommends operational testing to validate effectiveness of non-motion platforms
Place Published: Washington, DC
Date: March 26
Abstract: [full paper text below, under "Notes"]
Notes:
Regional Airline Industry White Paper
Government Research Indicates Simulator Motion Adds Training Complexity
RAA Recommends Operational Testing to Validate Effectiveness of Non-Motion Platforms
March 26, 2008

In order to maintain the current levels of safety in an increasingly complex airspace and airport environment, it is essential that transport category pilots acquire and maintain their piloting skills at the highest safety standard possible. With evolving aircraft technology and changing pilot new-hire demographics, ready access and effective, efficient use of advanced training tools is an absolute must. With “access” and “efficient” as the watchwords, there is growing debate on the value of non-motion platforms in flight simulators for transport category pilot training. This debate stems from mounting evidence that fixed-base non-motion devices equipped with wide field-of-view visual systems are as effective skill trainers as systems with motion. If the evidence developed in recent studies is correct, better utilization of non-motion training platforms would improve the training process by making advanced simulators more accessible, resulting in more efficient use of all training resources, both motion and non-motion.

RAA Joins Other Stakeholders in the Debate over the Value of Simulator Motion
Several stakeholders have already offered perspectives on this issue. The Air Line Pilots Association (ALPA) has produced a position paper endorsing a requirement for platform motion. An international working group recognized by the International Civil Aviation Organization (ICAO) is expected to recommend that the use of motion be required for most pilot training and checking. However, the Regional Airline Association (RAA) believes the mounting evidence, discussed in this paper, should be validated. RAA's Flight Training Committee, a standing committee of airline flight training department heads, has therefore developed this paper to draw attention to the issue, identify regional airlines as an important party to an invigorated discussion of the issue, and to develop and offer the regional airline industry's recommendations.

Research Indicates Motion Systems Add Training Complexity Without Adding Effectiveness
The FAA Air Traffic Organization (ATO) Operations Planning Research & Development Human Factors Research and Engineering Division commissioned the U.S. DOT Research and Innovative Technology Administration's Volpe Center to initiate a research program to determine the value of motion in transport pilot simulator flight training and evaluation.[1,2,3] Volpe enlisted NASA and MIT to help with the studies.

To date, three studies have tested over 100 pilots on initial and recurrent training in simulators representing three very different airplanes. The training tasks in these studies were specifically chosen for their potential to require platform motion. All equipment used in the studies satisfied or exceeded FAA qualification requirements. A fourth study is examining a new type of high-level simulator without platform motion that has been successfully used for Joint Aviation Regulation initial type rating on an experimental basis.[4, 5, 6, 7] The research program provides clear data indicating that simulator motion systems add cost and complexity to transport category pilot training without providing corresponding value in terms of training effectiveness.

The Current State of the Debate
In June 2006, ICAO hosted the inaugural meeting of an International Working Group (IWG) convened by the Royal Aeronautical Society to update the ICAO 9625 Manual of Criteria for the Qualification of Flight Simulators. ICAO pledged its "'full support for the project and the firm plan to publish the IWG results as ICAO documentation' – Paul Lamy, Chief Flight Safety Section, ICAO."[9] The IWG met in a series of closed sessions to establish simulator technical criteria and training credits. The revised and expanded ICAO manual is scheduled for publication in March 2008. Since a large portion of IWG membership consists of simulator manufacturers or their consultants, there is concern on the part of the airline industry that the IWG's position will strongly endorse the use of motion for all training and checking.

In September 2007, the ALPA Safety Committee published a paper titled "Safety Committee Statement of Position: The Need for Motion in Flight Simulation" reemphasizing their position that "the highest level of flight simulators shall be used to the maximum extent possible" for training and checking.[8]
While RAA has considered these opinions and absolutely supports this dialog, it is important to recognize that as the organizations ultimately responsible for the effectiveness of pilot training, the airlines are the most important stakeholders.

New Evidence Supports Testing Before Regulatory Changes are Made
The Regional Airline Association's Flight Training Committee is an executive committee of regional airline training department heads with primary responsibility for flight crew training and qualification. The Committee was briefed on the FAA/Volpe studies at their Fall 2007 meeting. The Committee members reviewed the research, debated the issues, and found merit in the conclusions that non-motion simulator platforms are undervalued in terms of their training benefit. The group concluded that the evidence

warrants a proof-of-concept evaluation that may support increasing regulatory credit for training provided on platforms without motion.

It is essential to move this issue from an emotional debate to one based upon hard data and logic. Airlines have a vested interest in this issue, and it is imperative that they make their voices heard before decisions by regulatory organizations are made that will limit their opportunities to use advanced training tools more effectively.

RAA Recommends Operational Testing to Validate the Research Findings

1) The RAA opposes any decisions by regulators that will close the door to alternatives to train and check transport pilots using full platform motion.

2) Based on the evidence cited, RAA recommends a proof-of-concept operational test of the effectiveness of flight training and checking, up to and including ATP certification and aircraft type rating, without the use of full platform motion.

Training Responsibility Rests Primarily with Regional Airlines

Mounting scientific evidence indicates that simulator platform motion adds little value to transport category pilot training.

The vast majority of RAA's members do not own their own simulators but rather "dry lease" the required time. Simulator lease rates are a "market-commodity cost" directly related to the number of simulators available. These commodity costs disproportionately affect smaller carriers and carriers operating unique aircraft types. The cost of platform motion represents an estimated 25% of the overall rental rate. Reducing the requirement of platform motion to train and check pilots would make advanced training devices more accessible, thereby improving aviation safety overall.

RAA is aware of mounting pressure from other organizations supporting regulations and policies mandating that all training and checking be conducted in full platform motion simulators. This approach may not be in the best interest of the regional airline industry or of flight safety.

The burden of the increasing demand for highly trained airline pilots and the consequential increase in resources necessary to training them is primarily carried by the regional airlines. It is in the interest of all stakeholders that the true value of each type of simulator be understood and credited against regulatory requirements. In doing so, this expanded knowledge will increase the efficiency of pilot training programs, improve the accessibility of the limited number of training simulators, and aid in the industry's efforts to maintain the highest safety standards.

About the Regional Airline Association

The Regional Airline Association (RAA) is a Washington, D.C. trade association that represents 43 North American regional airlines and the suppliers of products and services that support the industry.

References

[1]Longridge, T., Ray, P., Boothe, E., & Bürki-Cohen, J. (1996). Initiative towards more affordable flight simulators for U.S. commuter airline training. Proceedings of the Royal Aeronautical Society Conference on Training - Lowering the Cost, Maintaining the Fidelity, 15-16 May, London, UK, 2.1-2.17.

[2]Bürki-Cohen, J. (Ed.). Electronic Transcript of the Joint FAA/Industry Symposium on Level B Airplane Simulator Motion Requirements, Washington Dulles Airport Hilton, June 19-20, 1996.

[3]Bürki-Cohen, J., Soja, N.N., & Longridge, T. (1998). Simulator platform motion—The need revisited. International Journal of Aviation Psychology, 8 (3), 293-317.

[4]Go, T.H., Bürki-Cohen, J., & Soja, N.N. (2000). The effect of simulator motion on pilot training and evaluation. Proceedings of the AIAA Modeling and Simulation Technologies Conference, 14-17 August, Denver, CO, AIAA-2000-4296.

[5]Go, T.H., Bürki-Cohen, J., Chung, W. W., Schroeder, J., Saillant, G., Jacobs, S., & Longridge, T. (2003). The effects of enhanced hexapod motion on airline pilot recurrent training and evaluation. Proceedings of the AIAA Modeling and Simulation Technologies Conference, 11-14 August, Austin, TX, AIAA-2003-5678.

[6]Bürki-Cohen, J., & Go, T.H. (2005). The effect of simulator motion cues on initial training of airline pilots. Proceedings of the American Institute of Aeronautics and Astronautics Modeling and Simulation Technologies Conference, 15-18 August, San Francisco, CA, AIAA-2005-6109.
[7]Bürki-Cohen, J., Sparko, A.L., & Go, T.H. (2007). Training value of a fixed-base simulator with a dynamic seat. Proceedings of the American Institute of Aeronautics and Astronautics Modeling and Simulation Technologies Conference, 20-23 August, Hilton Head, SC, AIAA-2007-6564.
[8]ALPA (2007). Safety Committee Statement of Position: The need for motion in flight simulation.
[9]Tharp, Peter (2007, February 27). RAeS International Working Group (IWG) Flight Simulation Training Device (FSTD) Pilot Training and Qualification Standards. Presented at the Asia Pacific Airline Training Symposium (APATS) Bangkok. Retrieved January 22, 2007, from http://www.raes-fsg.org.uk/

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Reference Type: Web Page
Author: Regional Airlines Association (RAA)
Year: 1995
Title: Background on the single safety standard
Publisher: Regional Airlines Association (RAA)
Number of Pages: 3
Keywords: safety, "commuter rule," Regional Airlines Association (RAA), regional airlines, Part 121, Part 135
Abstract: Next month, the FAA is expected to announce new regulations that will establish a single safety standard for regional and major airlines. Under the regulatory requirements that exist today, there are a set of rules which apply to aircraft with more than 30 passenger seats and a second set of rules which apply to aircraft with up to 30 passenger seats.
The different set of rules exist because scheduled airline service provided by aircraft with 30 seats or less was very limited when the safety rules were first developed. With the rapid growth of the industry and the advent of increasingly sophisticated new aircraft, the Federal Aviation Administration and the airlines recognized the need for a single rule which would apply to all scheduled airline service operating aircraft with ten passenger seats or more.
The Regional Airline Association and its member companies are strong supporters of the single safety standard. The FAA rulemaking will further enhance safety, increase public appreciation for regional airline services, and help dispel the myth that two sets of regulations means two levels of safety. Under the new rules, all aircraft with ten seats and more will operate under the same regulatory requirements. These standards cover pilot training, pilot rest requirements, safety equipment, dispatching procedures, and every other area of airline and aircraft operations.
Notes: On October 17, 2001 the web page was no longer accessible.
URL: http://www.raa.org/therule.htm

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Reference Type: Report
Author: Reid, L. D.; Nahon, M. A.
Year: 1986
Title: Flight simulation motion-base drive algorithms: Part 3. Pilot evaluations
City: Toronto, Canada
Institution: Institute for Aerospace Studies, University of Toronto
Date: December
Report Number: UTIAS Report No. 319
CN ISSN 0082-5255
Author's Title and Affiliation: Reid: Ph.D., P. Eng. Professor
Abstract: This report covers the third and final phase of a project aimed at developing and testing flight simulator motion-vase drive algorithms suited to commercial jet transports. Full six degrees-of-freedom motion of a synergistic motion-base was studied. Three forms for these algorithms were considered:
(1) classical linear washout,
(2) optimal control,

(3) coordinated adaptive washout
It was felt that the latter two techniques might provide some advantages over the classical, which is currently employed in most commercial flight simulators. The aims of this project were to:
(1) develop the necessary equations,
(2) implement the necessary real-time software,
(3) evaluate the performance of the software with the help of airline pilots in a complete flight simulation
The present report describes the simulated aircraft and the flight scenarios employed during the evaluation process. The experimental plan and data gathering process are outlined fully. Both subjective pilot ratings and objective performance measures were obtained from seven pilots who evaluated ten different motion-base drive algorithm cases. In addition to using a direct pilot rating technique, about half of the experimental trials were used to obtain paired comparison results for four of the ten algorithm cases.
The pilot ratings, pilot comments and objective measures were analyzed and conclusions are presented based on this. The results highlight both pilot preferences in motion-based drive algorithms and the nature of pilot variability in assessing simulator motion quality.
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Reference Type: Conference Proceedings
Author: Reid, Lloyd D.; Nahon, Meyer A.
Year of Conference: 1987
Title: Response of airline pilots to flight simulator motion
Conference Name: AIAA Flight Simulation Technologies Conference
Conference Location: Monterey, CA
Publisher: American Institute of Aeronautics and Astronautics (AIAA)
Pages: 77-85
Series Title: Technical Papers (A87-49156 21-01)
Date: August 17-19
Electronic Resource Number: AIAA 87-2436
Author's Title and Affiliation: The University of Toronto Institute for Aerospace Studies, Toronto, Ontario, Canada
Keywords: airline pilots, flight simulator motion, six degrees-of freedom, UTIAS flight research simulator, washout
Abstract: The use of physical motion in flight simulation is still a much debated topic. This paper investigates the more narrow issue of its application in commercial jet transport simulators. We have attempted to quantify the perceptions of airline pilots about the quality of motion possible when a number of different motion-drive algorithms are tested on a simulator employing a state-of-the-art six-degrees-of-freedom motion-base. Four broad categories of algorithms are tested: classical washout, optimal control, coordinated adaptive, and no-motion. It was found that although there was little impact of the algorithm type on performance and control activity, there was a definite effect on how the pilots perceived the simulation environment. Based on these findings, it appears that the coordinated adaptive algorithm is generally preferred by the pilots over the algorithms tested. There was almost unanimous dislike of the no-motion case.

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Reference Type: Journal Article
Author: Reid, Lloyd D.; Nahon, Meyer A.
Year: 1988
Title: Response of airline pilots to variations in flight simulator motion algorithms
Journal: Journal of Aircraft
Volume: 25

Issue: 7
Pages: 639-646
Date: July
Electronic Resource Number: AIAA-0021-8669
Author's Title and Affiliation: Reid: Professor and Associate Director, Associate Fellow AIAA, University of Toronto Institute for Aerospace Studies, Toronto, Ontario, Canada
Nahon: Project Engineer, University of Toronto Institute for Aerospace Studies, Toronto, Ontario, Canada
Number of Pages: 8
Keywords: flight simulator motion algorithms, airline pilots, UTIAS, six-degrees-of-freedom, classical washout, visual displays, motion and visual cue timing, optimal controller
Abstract: The use of physical motion in flight simulation is still a much debated topic. This paper investigates the more narrow issue of its application in commercial jet transport simulators. We have attempted to quantify the perceptions of airline pilots about the quality of motion possible when a number of different motion-drive algorithms are tested on a simulator employing a state-of-the-art six-degrees-of-freedom motion-base. Four broad categories of algorithms were tested: classical washout, optimal control, coordinated adaptive, and no-motion. It was found that although there was little impact of algorithms type on performance and control activity, there was a definite effect on how the pilots perceived the simulation environment. Based on these findings, it appears that the coordinated adaptive algorithm is generally preferred by the pilots over the algorithms tested. There was almost unanimous dislike of the no-motion case.

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Reference Type: Report
Author: Reinach, Stephen
Year: 2001
Title: An examination of Amtrak's Acela High Speed Rail simulator for FRA research purposes
City: Waltham, MA
Institution: Foster-Miller Inc.
Date: April
Type: Technical Memorandum
Number of Pages: 80

*****

Reference Type: Conference Paper
Author: Reisman, Ron
Year: 1990
Title: A brief introduction to the art of flight simulation
Conference Name: Festival for Art, Technology and Society: Digital Dreams - Virtual Worlds
Publisher: Ars Electronica
Abstract: This essay presents a brief review of flight simulation technology. The theory is presented that flight simulation is the first and still the best form of virtual reality, and that the technology of flight simulation can be considered "lessons learned" and applied to other virtual reality endeavors. Special attention is paid to techniques for inducing the sensations of acceleration.
URL: http://www.aec.at/en/archiv_files/19902/E1990b_159.pdf

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Reference Type: Journal Article
Author: Ricard, Gilbert L.; Parrish, Russel V.
Year: 1984
Title: Pilot differences and motion cueing effects on simulated helicopter hover
Journal: Journal of Human Factors
Volume: 26
Issue: 3

Pages: 249-256
Author's Title and Affiliation: Ricard : Naval Training Equipment Center
Parrish : NASA Langley Research Center
Number of Pages: 7
Abstract: The effects that cues of aircraft motion, delays in visual scene, and movement of a ship model have on pilots' ability to hover a simulated helicopter near a destroyer-class ship were examined. Twelve pilots were tested in a within-subject factorial combination of fixed-base, moving-base, and G-seat conditions in which delays of 66 or 128 ms existed in the simulator's visual display and the pilots had to hover near a moving or stationary ship. Best control performance was seen under the moving-base conditions, whereas poorest control was associated with the fixed-base simulation. An intermediate level of performance was produced by the G-seat. In addition, visual delay affected control of the roll axis of the simulation, and interactions between pilots and motion cueing and visual delay were seen. Movement of the ship had little effect.

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Reference Type: Book Section
Author: Riccio, Gary E.
Year: 1995
Title: Coordination of postural control and vehicular control: Implications for multimodal perception and simulation of self motion
Editor: Flach, J.; Hancock, P.; Caird, J.; Vicente, K.
Book Title: The Ecology of Human-Machine Systems
City: Hillsdale, NJ
Publisher: Lawrence Erlbaum
Pages: 1-50 + Figures 1-13
Number of Pages: 63
Keywords: self motion, virtual environment, ecological psychology, control theory

*****

Reference Type: Report
Author: Riccio, Gary E.; McDonald, P. Vernon
Year: 1998
Title: Multimodal perception and multicriterion control of nested systems: I. Coordination of postural control and vehicular control
City: Houston, TX
Institution: National Aeronautics and Space Administration (NASA)
Date: January
Type: NASA Technical Paper
Report Number: Performing organization: S-835
Sponsoring organization: TP 3703
Author's Title and Affiliation: Riccio: Nascent Technologies, Ltd.
McDonald: KRUG Life Sciences, Inc.
Number of Pages: 66
Keywords: postural control, vehicular control, whole-body motion, locomotion, ecological psychology, control-systems engineering, motion, motion perception, perception, control, adaptive control
Abstract: The purpose of this report is to identify the essential characteristics of goal-directed whole-body motion. The report is organized into three major sections (Sections 2, 3, and 4). Section 2 reviews general themes from ecological psychology and control-systems engineering that are relevant to the perception and control of whole-body motion. These themes provide an organizational framework for analyzing the complex and interrelated phenomena that are the defining characteristics of whole-body motion. Section 3 of this report applies the organization framework from the first section to the problem of perception and control of aircraft motion. This is a familiar problem in control-systems engineering and ecological psychology. Section 4 examines an essential but generally neglected aspect of vehicular control: coordination of postural control and vehicular control. To facilitate presentation of this new idea,

postural control and its coordination with vehicular control are analyzed in terms of conceptual categories that are familiar in the analysis of vehicular control.
Notes: Performing organization: Lyndon B. Johnson Space Center
Sponsoring organization: NASA

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Reference Type: Conference Paper
Author: Rich, Henry H.
Year: 1989
Title: Tradeoffs in creating a low-cost visual simulator
Conference Name: Interservice/Industry Training, Simulation & Education (I/ITSEC) Conference
Conference Location: Raleigh, N.C.
Author's Title and Affiliation: Consultant, Star Technologies, Inc., Raleigh, NC
Number of Pages: 10
Abstract: Creating a low-cost visual system for training starts with deciding what features it will provide. Real-time training needs high scene content, photo-derived texture for realism, antialiasing, and careful attention to level of detail to avoid distracting the trainee; map-based CCCI needs fast access to large map databases; software and database development need integration into a workstation with full support for networking and windowing, including the ability to display training scenes under control of the windowing system. A visual system has three main components: a front end to manage the database, a geometric processor to compute the views of each element of the scene, and a shading processor to display the views. The design of each of these components provides a challenge to the system architect, with many old and new algorithms to be evaluated in the light of current technology. The most difficult problems are in shading, where the computational requirements of texturing call for parallel processing: we opted for processing full polygons in parallel, using MIP maps for texturing and a hybrid approach to hidden-surface removal. The front-end and geometry subsystems use easily-programmable processors to take advantage of coherency in the models and to provide flexibility for special effects.

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Reference Type: Report
Author: Riecke, B.; Schulte-Pelkum, J.; Caniard, F.; Bülthoff, H.
Year: 2005
Title: Spatialized auditory cues enhance the visually-induced self-motion illusion (circular vection) in Virtual Reality
City: Tübingen, Germany
Institution: Max Planck Institute for Biological Cybernetics
Date: October
Report Number: Technical Report No. 138
Author's Title and Affiliation: Department Bülthoff, Max Planck Institute for Biological Cybernetics, Spemannstr. 38, 72076 Tübingen, Germany
Abstract: “Circular vection” refers to the illusion of self-motion induced by rotating visual or auditory stimuli. Visually induced vection can be quite compelling, and the illusion has been investigated extensively for over a century. Rotating auditory cues can also induce vection, but only in about 25-60% of blindfolded participants (Lackner, 1977; Larsson et al., 2004). Furthermore, auditory vection is much weaker and far less compelling than visual vection, which can be indistinguishable from real motion. Here, we investigated whether an additional auditory cue (the sound of a fountain that is also visible in the visual stimulus) can be utilized to enhance visually induced self-motion perception. To the best of our knowledge, this is the first study directly addressing audio-visual contributions to vection. Twenty observers viewed rotating photorealistic pictures of a natural scene projected onto a curved projection screen (FOV: 54˚x45˚). Three conditions were randomized in a repeated measures within-subject design: No sound, mono sound, and spatialized sound using a generic head-related transfer function (HRTF). Adding mono sound to the visual vection stimulus increased convincingness ratings marginally, but did not affect vection onset time, vection buildup time, vection intensity, or rated presence. Spatializing the fountain sound such that it moved in accordance with the fountain in the visual scene, however, improved

vection significantly in terms of convincingness, vection buildup time, and presence ratings. The effect size for the vection measures was, however, rather small (<16%). This might be related to a ceiling effect, as visually induced vection was already quite strong without the spatialized sound (10s vection onset time). Despite the small effect size, this study shows that HRTF-based auralization using headphones can be employed to improve visual VR simulations both in terms of self-motion perception and overall presence. Note that facilitation was found even though the visual stimulus was of high quality and realism, and known to be quite powerful in inducing vection. These findings have important implications both for the understanding of cross-modal cue integration and for optimizing VR simulations.
URL: http://www.kyb.mpg.de/publications/attachments/Riecke_05_TR-138__Spatialized%20auditory%20cues%20enhance%20the%20visually-induced%20self-motion%20illusion%20(circular%20vection)%20in%20Virtual%20Reality_%5B0%5D.pdf
Author Address: bernhard.riecke@tuebingen.mpg.de

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Reference Type: Conference Paper
Author: Riecke, Bernhard E.; Schulte-Pelkum, Jorg; Avraamides, Marios N.; Bülthoff, Heinrich H.
Year: 2004
Title: Enhancing the visually induced self-motion illusion (vection) under natural viewing conditions in virtual reality
Conference Name: Presence
Conference Location: Valencia, Spain
Date: October 13-15
Keywords: vection, psychophysics, spatial presence, virtual reality, illusions, motion stimulation
Abstract: The visually induced illusion of ego-motion (vection) is known to be facilitated by both static fixation points and foreground stimuli that are perceived to be stationary in front of a moving background stimulus. In this study, we found that hardly noticeable marks in the periphery of a projection screen can have similar vection-enhancing effects, even without fixating or suppressing the optokinetic reflex (OKR). Furthermore, vection was facilitated even though the marks had no physical depth separation from the screen. Presence ratings correlated positively with vection, and seemed to be mediated by the ego-motion illusion. Interestingly, the involvement/attention aspect of overall presence was more closely related to vection onset times, whereas spatial presence-related aspects were more tightly related to convincingness ratings. This study yields important implications for both presence theory and motion simulator design and applications where one often wants to achieve convincing ego-motion simulation without restricting eye movements artificially.
URL: http://www.temple.edu/ispr/prev_conferences/proceedings/2004/Riecke,%20Schulte-Pelkum,%20Avraamides,%20Bulthoff.pdf

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Reference Type: Conference Proceedings
Author: Riecke, Bernhard E.; Schulte-Pelkum, Jörg; Caniard, Franck; Bülthoff, Heinrich H.
Year of Conference: 2005
Title: Influence of auditory cues on the visually-induced self-motion illusion (circular vection) in virtual reality
Conference Name: 8th International Workshop on Presence
Conference Location: London, UK
Date: September 21-23
Author's Title and Affiliation: Max Planck Institute for Biological Cybernetics, Tübingen, Germany
Keywords: vection, self-motion perception, spatial orientation, virtual reality, motion simulation, human factors, psychophysics, multi-modal cue integration, auditory cues, HRTF
Abstract: This study investigated whether the visually induced self-motion illusion ("circular vection") can be enhanced by adding a matching auditory cue (the sound of a fountain that is also visible in the visual stimulus). Twenty observers viewed rotating photorealistic pictures of a market place projected onto a curved projection screen (FOV: 54x45˚). Three conditions were randomized in a repeated measures within-subject design: No sound, mono sound, and spatialized sound using a generic head-related

transfer function (HRTF). Adding mono sound increased convincingness ratings marginally, but did not affect any of the other measures of vection (convincingness and vection buildup time) and presence ratings significantly. Note that facilitation was found even though the visual stimulus was of high quality and realism, and known to be a powerful vection-inducing stimulus. Thus, HRTF-based auralization using headphones can be employed to improve visual VR simulations both in terms of self-motion perception and overall performance.

URL:
http://www.kyb.mpg.de/publications/attachments/Riecke__05_paper4Presence2005_Influence_of_Auditory_Cues_on_the_visually-induced_Self-Motion_Illusion_-Circular_Vection-_in_Virtual_Reality_3466[0].pdf

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Access Date: August 15, 2007

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Reference Type: Conference Proceedings
Author: Riecke, Bernhard E.; Schulte-Pelkum, Jörg; Caniard, Franck; Bülthoff, Heinrich H.
Year of Conference: 2005
Title: Toward lean and elegant self-motion simulation in virtual reality
Conference Name: Virtual Reality
Conference Location: Bonn, Germany
Publisher: Institute of Electrical and Electronics Engineers (IEEE)
Pages: 131- 38
Date: March 12-16
Author's Title and Affiliation: Max Planck Institute for Biological Cybernetics, Tübingen, Germany
Keywords: vection, self-motion illusion, spatial orientation, virtual reality, motion simulation, human factors, psychophysics, multi-modal cue integration, vibrations, auditory cues

Abstract: Despite recent technological advances, convincing self-motion simulation in Virtual Reality (VR) is difficult to achieve, and users often suffer from motion sickness and/or disorientation in the simulator world. Instead of trying to simulate self-motions with physical realism (as is often done for, e.g., driving or flight simulators), we propose in this paper a perceptually oriented approach towards self-motion simulation. Following this paradigm, we performed a series of psychophysical experiments to determine essential visual, auditory, and vestibular/tactile parameters for an effective and perceptually convincing self-motion simulation. These studies are a first step towards our overall goal of achieving lean and elegant self-motion simulation in Virtual Reality (VR) without physically moving the observer. In a series of psychophysical experiments about the self-motion illusion (circular vection), we found that (i) vection as well as presence in the simulated environment is increased by a consistent, naturalistic visual scene when compared to a sliced, inconsistent version of the identical scene, (ii) barely noticeable marks on the projection screen can increase vection as well as presence in an unobtrusive manner, (iii) physical vibrations of the observer's seat can enhance the vection illusion, and (iv) spatialized 3D audio cues embedded in the simulated environment increase the sensation of self-motion and presence. We conclude that providing consistent cues about self-motion to multiple sensory modalities can enhance vection, even if physical motion cues are absent. These results yield important implications for the design of lean and elegant self-motion simulators.

URL: http://www.kyb.tuebingen.mpg.de/publications/pdfs/pdf2904.pdf

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Access Date: August 15, 2007

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Reference Type: Conference Proceedings
Author: Riecke, B.E.; Västfjäll, D.; Larsson, P.; Schulte-Pelkum, J.
Year of Conference: 2005
Title: Top-down and multi-modal influences on self-motion perception in virtual reality
Conference Name: 1st International Conference on Virtual Reality, part of the 11th International Conference on Human Computer Interaction (HCI International 2005)
Author's Title and Affiliation: Riecke: Max Planck Institute for Biological Cybernetics, Tübingen, Germany
Västfjäll: Chalmers University of Technology, Götegorg, Sweden
Larsson: Chalmers University of Technology, Götegorg, Sweden
Schulte-Pelkum: Max Planck Institute for Biological Cybernetics, Tübingen, Germany
Abstract: INTRODUCTION: Much of the work on self-motion perception and simulation has investigated the contribution of physical stimulus properties (so-called "bottom-up" factors). This paper provides an overview of recent experiments demonstrating that illusory self-motion perception can also benefit from "top-down" mechanisms, e.g., expectations, the interpretation and meaning associated with the stimulus, and the resulting spatial presence in the simulated environment. METHODS: Several VR setups were used as a means to independently control different sensory modalities, thus allowing for well-controlled and reproducible psychophysiological experiments. Illusory self-motion perception (vection) was induced using rotating visual or binaural auditory stimuli, presented via a curved projection screen (FOV: 54 x 40.5˚) or headphones, respectively. Additional vibrations, subsonic sound, or cognitive frameworks were applied in some trials. Vection was quantified in terms of onset time, intensity, and convincingness ratings. RESULTS & DISCUSSION: Auditory vection studies showed that sound sources participants associated with stationary "acoustic landmarks" (e.g., a fountain) can significantly increase the effectiveness of the self-motion illusion, as compared to sound sources that are typically associated with moving objects (like the sound of footsteps). A similar top-down effect was observed in a visual vection experiment: showing a rotating naturalistic scene in VR improved vection considerably compared to scrambled versions of the same scene. Hence, the possibility to interpret the stimulus as a stationary reference frame seems to enhance the self-motion illusion perception, which challenges the prevailing opinion that self-motion perception is primarily bottom-up driven. Even the mere knowledge that one might potentially be moved physically increased the convincingness of the self-motion illusion significantly, especially when additional vibrations supported the interpretation that one was really moving. CONCLUSIONS: Various top-down mechanisms were shown to increase the effectiveness of self-motion simulations in VR, even though they have received little attention in the literature up to now. Thus, we posit that a perceptually-oriented approach that combined both bottom-up and top-down factors will ultimately enable us to optimize self-motion simulations in terms of both effectiveness and costs.
URL: http://www.kyb.mpg.de/publications/attachments/Riecke__05__VE_HCI2005__Top-Down_and_Multi-Modal_Influences_on_Self-Motion_Perception_in_Virtual_Reality__asOnConferenceCD_2252_2765%5B0%5D.pdf
Author Address: Riecke: bernhard.riecke@tuebingen.mpg.de
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Reference Type: Conference Paper
Author: Ringland, Robert F.; Stapleford, Robert L.
Year: 1971
Title: Motion cue effects on pilot tracking
Conference Name: Annual Conference on Manual Control
Conference Location: Los Angeles
Author's Title and Affiliation: Systems Technology, Inc.
Number of Pages: 12
Abstract: The results of two successive experimental investigations of the effects of motion cues on manual control tracking tasks are reported. The first of these was an IFR single-axis VTOL roll attitude control task. Describing function data show the dominant motion feedback quantity to be angular velocity.

The second experimental task was multiaxis, that of precision hovering of a VTOL using separated instrument displays with reduced motion amplitude scaling. Performance data and pilot opinion show angular position (i.e., g-vector tilt) to be the dominant cue when simulator linear motion is absent.

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Reference Type: Conference Proceedings
Author: Risser, Matthew R.; McNamara, Danielle S.; Baldwin, Carryl L.; Scerbo, Mark W.; Barshi, Immanuel
Year of Conference: 2002
Title: Interference effects on the recall of words heard and read: Considerations for ATC communcation
Conference Name: Human Factors and Ergonomics Society 46th Annual Meeting
Pages: 392-396
Date: 2002
Number of Pages: 6
Abstract: Two experiments were conducted to investigate the effects of interference on memory for words that were either read or heard. Interference tasks required either visual, verbal, or central executive (CE) working memory resources. Experiment 1 examined effects of simultaneous interference, whereas Experiment 2 examined the effects of posttask (subsequent) interference. When interference occurred simultaneously with word presentation, the verbal and CE interference tasks were most disruptive, regardless of whether the words were read or heard. Furthermore, hearing words facilitated recall in comparison to reading words regardless of interference source. When the interference task followed word presentation, CE interference again was the most disruptive. However, the effects of the visual and verbal interference tasks were equivalent. These results are discussed with respect to communication mode in ATC messages to pilots (i.e., textual data-link messages vs. voice transmissions).

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Reference Type: Conference Proceedings
Author: Risser, Matthew R.; Scerbo, Mark W.; Baldwin, Carryl L.; McNamara, Danielle S.
Year of Conference: 2003
Title: ATC commands executed in speech and text formats: Effects of task interference
Conference Name: 12th Biennial International Symposium on Aviation Psychology
Conference Location: Dayton, OH
Pages: 999-1004
Number of Pages: 6
Abstract: The present study examined effects of interference on the ability to execute commands presented in either a speech or text format. Participants either read or listened to simulated ATC procedural commands and executed them on a simulated control panel. Interference tasks required visual, verbal, or central executive (CE) working memory resources and were presented concurrently with the commands in Experiment 1 and immediately subsequent to the commands in Experiment 2. The results suggest that CE and verbal interference disrupts the ability to remember and execute procedural commands regardless of whether commands are presented in a speech or text format. Additionally, secondary task performance is most affected by intra-modal interference. Results are discussed with respect to performance implications for the reception of ATC messages on the flight deck.

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Reference Type: Electronic Article
Author: Roach, John
Year: 2006
Title: New icing detection system for U.S. airplanes debuts
Periodical Title: National Geographic News
Keywords: icing detection system, current icing product (CIP)
URL: http://news.nationalgeographic.com/news/pf/85558745.html
Access Date: July 10, 2008

Reference Type: Conference Paper
Author: Roberts, M. E. C.; Murray, P. M.
Year: 1986
Title: Optical flow - The key to integration of visual and vestibular motion cueing
Conference Name: RAeS Advances in Flight Simulation - Visual and Motion Systems
Publisher: Royal Aeronautical Society (RAeS)
Author's Title and Affiliation: Rediffusion Simulation, U.K.
Number of Pages: 13
Abstract: 1. Visual and Motion
The limitations of motion simulators and visual simulation and their non-linear interaction with the human senses tend to make difficult the prediction of the integrated performance of the two systems. This paper is an Engineer's attempt to examine major factors involved in the integration so that separate measures of performance of these two systems can lead to a better prediction of integrated performance.

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Reference Type: Magazine Article
Author: Robinson, Clarence A., Jr.
Year: 1996
Title: Synthetic training duplicates emergency cockpit conditions
Magazine: SIGNAL Magazine
Pages: 1-4
Date: July
Number of Pages: 4
Keywords: reflectone, virtual reality

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Reference Type: Magazine Article
Author: Robinson, Tim
Year: 2009
Title: Embracing the New Reality
Magazine: Aerospace International

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Reference Type: Conference Paper
Author: Rodchenko, V. V.; Boris, S. Y.; White, A. D.
Year: 2000
Title: In-flight estimation of pilots' acceleration sensitivity thresholds
Conference Name: AIAA Modeling and Simulation Technologies Conference and Exhibit
Conference Location: Denver, CO
Publisher: American Institute of Aeronautics and Astronautics (AIAA)
Date: August 14-17
Electronic Resource Number: AIAA-2000-4292
Author's Title and Affiliation: Rodchenko: Head of Section, Central Aerohydrodynamics Institute (TsAGI), Russia
Boris: Deputy Director of Research Center, Flight Research Institute (FRI), Russia
White: Principal Scientist, Defence Evaluation and Research Agency (DERA), UK
Number of Pages: 8
Abstract: A Tu-154 in-flight simulator was used to estimate pilots' sensitivity thresholds for normal, roll and pitch accelerations and to investigate the effect of normal acceleration on angular acceleration sensitivity thresholds. These in-flight experiments were partly reproduced in an on-ground moving-base simulator (FS-102).
Pilot sensitivity thresholds for specific forces and angular accelerations in flight and on the ground were compared. The experiments showed that, due to certain flight factors not normally reproduced on the

ground, pilot sensitivity thresholds for normal accelerations in flight can considerably exceed those experienced in ground-based simulators. The experiments showed that, in ground-based simulators, lateral specific forces arising from cockpit tilt can cause considerable errors in estimating sensitivity thresholds for roll motion.
In-flight experimental data on pilot perception of low-frequency normal accelerations (for frequencies as low as 0.25rad/s) and the influence of these accelerations on pilot sensitivity to angular motion were generated. Such low frequency data cannot be obtained using ground-based simulators.

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Reference Type: Report
Author: Rogers, Ron
Year: 1999
Title: Pilot authority and aircraft protections
Institution: Air Line Pilots Association (ALPA) Airworthiness Performance Evaluation and Certification Committee,
Date: March 1
Author's Title and Affiliation: Captain Ron Rogers, Group Chairman
Number of Pages: 54
Keywords: fly-by-wire (FBW), flight envelope protection, upset recovery training (URT)
Abstract: Modern airliners are equipped with many systems designed to protect the aircraft and its occupants from harm. These systems range from simple warning devices to complex envelope protections. The modern Fly-By-Wire (FBW) flight control systems with their flight envelope protection features have the potential of offering significant safety benefits over the protection features of aircraft with conventional flight control systems.
The addition of various protection systems has tended to impove airline accident rates over the years. Occasionally however, some of the very systems designed to protect the aircraft have contributed to accidents. This opposite effect of the onboard safety systems seems to be the result of inadequate or incomplete design, or the occurence of unanticipated events. In those cases where the safety system itself was causal to an accident, the flight crew was often unable to counter the effects of the system. This paper presents a discussion of the evolution of aircraft protection schemes and lessons learned, along with design recommendations for aircraft systems.
URL: http://www.rvs.uni-bielefeld.de/publications/Incidents/DOCS/Research/Other/Article/RogReports/Rogers_99_Acft_Protect.pdf

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Reference Type: Report
Author: Rogers, Rodney O.; Boquet, Albert; Howell, Cass; DeJohn, Charles
Year: 2007
Title: Preliminary results of an experiment to evaluate transfer of low-cost simulator-based airplane upset-recovery training
City: Washington, DC
Institution: Embry-Riddle Aeronautical University & FAA Civil Aerospace Medical Institute
Date: October
Report Number: DOT/FAA/AM-07/27
Author's Title and Affiliation: Rogers, Boquet, & Howell: Embry-Riddle Aeronautical University
DeJohn: FAA Civil Aerospace Medical Institute
Recipient's Title and Affiliation: Office of Aerospace Medicine, Federal Aviation Administration (FAA)
Keywords: airplane upset-recovery training (URT), low-cost flight simulation, training transfer
Abstract: Many air transport training programs provide simulator-based upset-recovery instruction for company pilots. However, no research exists to demonstrate that such training transfers to an airplane in flight. We report on an in-progress FAA-funded research experiment to evaluate upset-recovery training transfer. Participant pilots are trained using low-cost desktop flight simulation, then subjected to serious in-flight upsets in an aerobatic airplane. Preliminary results comparing the performance of trained and

control group pilots suggest that simulator-based training may improve a pilot's ability to recover an airplane from an upset. We summarize prior research, describe the experiment, and present results of Phase-One testing. We also detail planned refinements in Phase-Two flight training and testing that we hope will strengthen the results of our research. Although we are conducting flight testing in a general aviation airplane, our research has important implications for heavy aircraft upset recovery trainers.
URL: http://www.faa.gov/library/reports/medical/oamtechreports/2000s/media/200727.pdf
Author Address: Embry-Riddle Aeronautical University, Daytona Beach, FL 32114
FAA Civil Aerospace Medical Institute, P.O. Box 25082, Oklahoma City, OK 73125

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Reference Type: Report
Author: Rogers, Rodney O.; Boquet, Albert; Howell, Cass; DeJohn, Charles
Year: 2009
Title: An experiment to evaluate transfer of low-cost simulator-based upset-recovery training
Date: Mar 2009
Report Number: DOT/FAA/AM-09/5

Number of Pages: 20
Accession Number: 01135607
Keywords: air pilots, aviation safety, flight simulators, flight training, upset recovery training (URT)
Abstract: Many air transport training programs provide simulator-based upset-recovery instruction for company pilots. However, apparently no prior research exists to demonstrate that such training transfers to an airplane in flight. We report on a two-phase FAA-funded research experiment to evaluate upset-recovery training transfer. In two separate training/testing evolutions involving two different general aviation aircraft, participant pilots were trained using low-cost desktop flight simulation, then subjected to serious in-flight upsets in an aerobatic airplane. Their performance in upset-recovery maneuvering was compared with the performance of control group pilots who received no upset-recovery training. Data collected during both flight testing periods suggest that simulator-based training improves a pilot's ability to recover an airplane from an upset. However, in the most important measure of upset maneuvering skills-minimizing altitude loss-trained pilots fell well short of the performance routinely achieveable by pilots experienced in all-attitude manuevering. We summarize prior related research, describe the experiments, present and analyze data collected during both flight testing periods, and advance recommendations for future upset maneuvering training. Although we conducted flight testing in a general aviation airplane, our research has important implications for heavy aircraft upset-recovery trainers.
URL: http://faa.gov/library/reports/medical/oamtechreports/2000s/media/200905.pdf

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Reference Type: Conference Paper
Author: Rolfe, John
Year: 1996
Title: Twenty-five years of flight simulation - or - It's a long time since I lost a buddy in a training accident
Conference Name: Royal Aeronautical Society Spring Conference
Publisher: Royal Aeronautical Society (RAeS), AirSpace Flight Simulation Group
Abstract: (first two paragraphs) Twenty five years in no way encompasses the history of flight simulation, so why choose this time to look back? Two events prompted this article. The first was that in 1970 the Royal Aeronautical Society held its first conference devoted to flight simulation. The success of the conference generated interest and support for the formation of the Society's Flight Simulation Group. Since then the Group has maintained a highly successful international conference program. Moreover, the Group has taken a number of productive initiatives to enhance understanding and encourage progress in the design and use of flight simulation. This article draws on the activities of the Group to consider the changes that have taken place and the progress that has been achieved.
The second reason for the title was that in 1971 Flight International published an article from me entitled 'The Future of Simulation'. In it I concluded that simulation, at a range of levels, had the potential to play a much greater role in aircrew training. To achieve this objective would require addressing the issue of

motivating both users and legislators to accept simulation as a means of acquiring and maintaining competency. Twenty-five years later I will attempt to assess how accurate I was.
Notes: This may have been originally released in 1996. The current version includes a copyright from the Royal Aeronautical Society 1999.
URL: http://www.raes-fsg.org.uk/19/Twenty_Five_Years_of_Flight_Simulation/

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Reference Type: Journal Article
Author: Rolfe, J. M.; Hammerton-Fraser, A. M.; Poulter, R. F.; Smith, E. M. B.
Year: 1970
Title: Pilot response in flight and simulated flight
Journal: Ergonomics
Volume: 13
Issue: 6
Pages: 761-768
Author's Title and Affiliation: All: Royal Air Force Institute of Aviation Medicine
Number of Pages: 8
Abstract: This paper describes an experiment in which an attempt was made to assess the value of two types of response, control activity and physiological activity, as indications of the effect on simulator fidelity of adding pitch motion cues. The investigation used a general-purpose research simulator and a two-seater Hunter T7 aircraft. The responses of nine experienced pilots were compared when, flying on instruments, they undertook the same flight plan under three different conditions namely:
flight in the Hunter T7 aircraft:
simulated flight in the simulator with pitch motion present;
simulated flight in the same simulator without motion.

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Reference Type: Journal Article
Author: Rolfe, J. M.; Hampson, B. P.
Year: 2003
Title: Flight simulation - Viability versus liability issues of accuracy, data and validation
Journal: The Aeronautical Journal
Volume: 107
Issue: 1976
Pages: 631-635
Date: October
Author's Title and Affiliation: Rolfe: Filled Roles Simulations; Hemingford Grey, UK
Hampson: Training Technology International; Beaconsfield, Canada
Abstract: Flight simulation has become an indispensible tool for aviation training. Important decisions relating to the acquisition and certification of aircrew proficiency are made based on performance in simulated flight conditions. Such a high dependency on simulation can invite questions about the validity of the assumptions on which their employment is founded. If these should be shown to be in any way deficient, those who consider that they have suffered as a result may seek redress. The paper considers the possibility that such conditions could arise and require those involved in the design, manufacture, regulation and operation of flight simulators to justify their decisions. The paper suggests that the culture should be one which acknowledges that simulation has its limitations and, consequently, exercises a duty of care for those who undertake training and assessment in flight simulators.

Reference Type: Edited Book
Editor: Rolfe, J. M.; Staples, K. J.
Year: 1986
Title: Flight simulation
Series Title: Cambridge Aerospace Series
City: Cambridge, UK
Publisher: Cambridge University Press
Edition: Paperback
ISBN: ISBN 0-521-35751-9
Author's Title and Affiliation: Rolfe: Senior Principal Psychologist, Ministry of Defence
Staples: Royal Aircraft Establishment, Bedford

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Reference Type: Journal Article
Author: Rolnick, Arnon; Lubow, R. E.
Year: 1991
Title: Why is the driver rarely motion sick? The role of controllability in motion sickness
Journal: Ergonomics
Volume: 34
Issue: 7
Pages: 867-879
Author's Title and Affiliation: Rolnick: Israeli Naval Hyperbaric Institute, Motion Sickness and Human Performance Laboratory, Haifa, Israel
Lubow: Tel-Aviv University, Department of Psychology, Tel-Aviv, Israel
Number of Pages: 13
Keywords: motion sickness, controllability, stress (psychological)
Abstract: The central hypothesis of the work is that the dimension of control-no control plays an important role in motion sickness. Although it is generally agreed that having control over a moving vehicle greatly reduces the likelihood of motion sickness, few studies have addressed this issue directly, and the theoretical explanation for this phenomenon is not completely clear. In the study, we equated groups differing in controllability for head movement, vision, activity, and predictability, which have often been suggested in the literature as explanations for the driver's immunity to motion sickness. Twenty-two pairs of yoked subjects were exposed to nauseogenic rotation. One subject of each pair had control over the rotation and head movements, while the other was exposed passively to the same motion stimulus. Subjects who had control reported significantly fewer motion sickness symptoms and less of a decrement in their well-being, as compared to the yoked subject without control. The results are discussed in relation to Reason's sensory rearrangement theory and the concept of feed-forward mechanisms in motion perception.

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Reference Type: Conference Proceedings
Author: Romano, Richard
Year of Conference: 2001
Title: Round table discussion: Motion cueing issues
Conference Name: 1st Human Centered Transportation Simulation Conference
Conference Location: Iowa City, Iowa
Date: November 4-7

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Reference Type: Journal Article
Author: Roscoe, S. N.
Year: 1991
Title: Simulator qualification: Just as phony as it can be
Journal: International Journal of Aviation Psychology (IJAP)
Volume: 1
Issue: 4
Pages: 335-339
Author's Title and Affiliation: ILLIANA Aviation Sciences Limited, Arcata, CA and Las Cruces, NM
Number of Pages: 5
Abstract: The qualification of airplane simulators for pilot training is based on the assumption that transfer of such training is directly related to the similarity of the device to an actual airplane. The consequence of this widely held position has been the specification of training device requirements solely on the basis of engineering criteria. However, the proper criterion is the flight hours saved in airborne training for each incremental investment in ground training. Furthermore, research has shown that innovation in training strategies, in some cases involving intentional departures from reality, can have stronger effects than high simulator fidelity on the resulting quality of pilot performance. Ideally, each aspect of the training curriculum could be taught to some criterion performance level on the ground. Competence in each block of training would be demonstrated after a brief transition in the airplane. Certification for each license and rating would be based on demonstrated competence, thereby making possible large reduction in the minimum required flying hours. Credit for ground-based training would no longer be a formal issue.
URL: http://www.leaonline.com/doi/pdf/10.1207/s15327108ijap0104_6

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Reference Type: Journal Article
Author: Roscoe, S. N.
Year: 2002
Title: Ergavionics: Designing the job of flying an airplane
Journal: International Journal of Aviation Psychology
Volume: 12
Issue: 4
Pages: 331-339
Number of Pages: 9
Accession Number: 00935790
Keywords: aircraft pilotage, aviation safety, cockpits, control devices, design, flight simulators, information display systems, navigational aids, technological innovations
Abstract: Ergavionic principles governing the design and operation of an airplane cockpit were discovered through simulator and flight experiments starting during World War II and continuing through the 1970s, but their systematic application has not happened. These principles deal with control location and operation, display integration and pictorial realism, and control/display direction-of-motion relationships. Systematic application of these principles would make the job of flying an airplane so much easier and safer that hundreds of lives would be saved every year, and in the decades to come, thousands of lives.

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Reference Type: Research Paper
Author: Roscoe, Stanley N.
Year: 2002
Title: The transfer of training effectiveness of personal Computer Aviation Training Devices (PCATDs)

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Reference Type: Journal Article
Author: Roscoe, Stanley N.
Year: 2004
Title: Moving horizons, control reversals, and graveyard spirals
Journal: Ergonomics in Design
Volume: Q4
Pages: 15-19
Number of Pages: 6
Abstract: Might an attitude display with a flight path predictor help to prevent accidents such as the JFK Jr. crash in 1999?

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Reference Type: Journal Article
Author: Roscoe, Stanley N.; Williges, Robert C.
Year: 1975
Title: Motion relationships in aircraft attitude and guidance displays: A flight experiment
Journal: Human Factors
Volume: 14
Issue: 4
Pages: 374-387
Author's Title and Affiliation: University of Illinois at Urbana-Champaign
Number of Pages: 14
Keywords: students, motion reactions, display systems, attitude indicators, cathode ray tube screens, flight instruments, flight testing, human factors engineering, performance (human), optical tracking, command guidance, analysis of variance
Abstract: Sixteen nonpilot Naval ROTC students were tested on tasks involving conflicting visual and vestibular cues while flying with each of four basic aircraft attitude presentations (moving horizon, moving airplane, frequency-separated, and kinalog) in a Beechcraft C-45H airplane. Flight-director versions of each display presenting either compensatory or pursuit steering guidance were also compared to a command flight path tracking task involving random heading changes. For all attitude presentations, pursuit tracking was superior to compensatory tracking and the order of merit of the four attitude presentations in flight casts doubt upon the validity of previous simulator experiments. It was concluded that the principle of display frequency separation provides at least equivalent pilot steering performance to that obtained with the conventional moving horizon format, while the anticipatory cues it affords tends to reduce the incidence of control reversals under circumstances of subliminal angular acceleration by providing initial direction-of-motion compatibility.

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Reference Type: Journal Article
Author: Rosenkopf, Lori; Tushman, Michael L.
Year: 1998
Title: The coevolution of community networks and technology: Lessons from the flight simulation industry
Journal: Industrial and Corporate Change
Volume: 7
Pages: 311-346
Author's Title and Affiliation: Rosenkopf: The Warton School, University of Pennsylvania, 2000 Steinberg Hall - Dietrich Hall, Philadelphia, PA 19104-6370
Tushman: Graduate School of Business, Columbia University, 719 Uris Hall, New York, NY 10027
Number of Pages: 30, plus Figures
Abstract: We explore how interorganizational networks coevolve with technology in the modern flight simulation industry. Since industries characterized by complex technologies, like flight simulation, rely on cooperative groups such as technical committees, task forces, and standards bodies to adjudicate the process of technological evolution, we focus on these groups and term them "cooperative technical organizations" (CTOs). Focusing on CTOs enables a multi-level examination of interorganizational

networks, as individuals represent their employing organizations in CTOs, mapping into overlapping membership patterns which generate community-wide networks.
We develop a set of propositions on the emergence, growth and re-formation of CTO networks, and explore how the evolution of these networks both shapes and is constrained by technological outcomes in the flight simulation industry. We argue that varying levels of technological uncertainty between eras of ferment (high uncertainty) and eras of incremental change (low uncertainty) engender fundamentally different modes of network evolution: social construction during eras of ferment, and technological determinism during eras of incremental change. More specifically, during the era of ferment, movement of new members into the CTO community enables the re-formation of interorganizational networks which select among competing technological alternatives. The selection of a dominant design, however, constrains the evolution of network structure, as subsequent CTO membership remains relatively consistent. These dynamics have strategic implications for firms, as the era of ferment presents a window of opportunity where firms must seek to manage these community-level networks and selection process to their advantage.

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Reference Type: Magazine Article
Author: Rosenkrans, Wayne
Year: 2008
Title: Helping hand
Magazine: AeroSafety World
Pages: 17-21
Date: June
Keywords: auto-recovery, upset recovery training (URT)
Abstract: Auto-recovery systems would 'refuse to be destroyed' by a flight crew's inaction, delay or incorrect response to an imminent collision.
URL: http://www.flightsafety.org/pubs/asw_2008.html

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Reference Type: Journal Article
Author: Rosenkrans, Wayne
Year: 2009
Title: Attitude adjustment
Journal: Aero Safety World
Pages: 34-39
Number of Pages: 6
URL: http://flightsafety.org/asw/feb09/asw_feb09_p34-39.pdf

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Reference Type: Journal Article
Author: Rosenkrans, Wayne
Year: 2010
Title: Virtually Interactive
Journal: Aero Safety World
Volume: 5
Issue: 6
Pages: 38-42
Date: July 2010
Number of Pages: 5
URL: <http://flightsafety.org/aerosafety-world-magazine/july-2010/virtually-interactive>

Reference Type: Book
Author: Rosenthal, R.; Rosnow, R. L.
Year: 1991
Title: Essentials of behavioral research methods and data collection
Publisher: McGraw-Hill
Number of Pages: 692
Edition: 2nd
Author's Title and Affiliation: Robert Rosenthal: Harvard University
Ralph L. Rosnow: Temple University

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Reference Type: Magazine Article
Author: Rossier, Robert N.
Year: 2004
Title: The lessons we forget
Magazine: Business & Commercial Aviation
Pages: 50
Date: September 1
Keywords: upset recovery training (URT), distraction, disorientation, illusions
Abstract: News of the settlement reached between the families of five Oklahoma State University basketball players and the estates of two pilots killed in the crash of a chartered Super King Air 200 in January 2001 recently came out. It's a sobering reminder of how things can go wrong -- dead wrong -- on a seemingly routine flight.

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Reference Type: Journal Article
Author: Rouse, William B.; Gopher, Daniel
Year: 1977
Title: Estimation and control theory: Application to modeling human behavior
Journal: Human Factors
Volume: 19
Issue: 4
Pages: 315-329
Date: August
Author's Title and Affiliation: Rouse: University of Illinois at Urbana-Champaign
Gopher: The Technion, Haifa, Israel
Number of Pages: 15
Abstract: The methodology of estimation and control theory is considered in terms of response, stability, estimation, and control of linear dynamic systems. Within the context of discrete-time systems, multi-input, multi-output, n^{th}-order linear systems are discussed, and general results for optimal estimation, optimal control, and other topics are presented. The application of these results to modeling human behavior is considered with special emphasis on man-machine system models.

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Reference Type: Table of Contents
Author: Royal Aeronautical Society (RAeS)
Year: 1981, 1982, 1986, 1987, 1989
Title: Flight simulation papers
Notes: Table of contents only

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Reference Type: Conference Proceedings
Author: Royal Aeronautical Society (RAeS)
Year of Conference: 1992
Title: Proceedings of Matching Technology to Training Requirements
Conference Name: European Forum on Matching Technology to Training Requirements
Publisher: Royal Aeronautical Society (RAeS)
Date: May 19-20
Notes: Paper titles:
1) Area of Interest Parameters for Effective Pilot Training (By Hodgson, Murray, and Plummer)
2) Simulator Computer Systems - Technology for the 1990s (By Burgin)
3) Improved Reliability (By Irving)
4) An Instructor Station for the Instructor (By Goode and Evans)
5) The Civilian Simulator - A User's View (By Hall)
6) Quick-Response Training System Modification and its Impact on Army Aviation Sustainment Training (By Matusof, Polkowski, and Fullmer)
7) Issues in Training Device Design (By Wilson)
8) Full Mission Simulation - An Operator's View (By Williams)
9) The Advanced Qualification Program: Matching Technology to Training Requirements (By Longridge)
10) Beyond AQP - Broad Spectrum Product Family Integration for Aircrew Training (By Francis and Heybroek)
11) The Cost Effective Flight Training Device (By Prime)
12) Flight Training Devices - Meeting the Low-End Requirements (By Upton)
13) The Simulation of Taxiing Aircraft (By Hogg, Self, Pearce, and Kapadoukas)
14) A Case for Simulator Motion Standards (By Boothe)
15) Some Considerations for the Definition of Motion Cue Validation Tests (By Luijt and van de Moesdijk)
16) Analysis and Development of Advanced Techniques for Cueing the Force and Motion Environment in the Simulator of the Future (By Cardullo and McMillan)
17) Designing a Truly Portable Simulation Application - It Can Be Done (By Nutt)

*****

Reference Type: Report
Author: Royal Aeronautical Society (RAeS)
Year: 1995
Title: Use of engineering simulator data as a supplement to flight test data to support flight simulator qualification for modified or derivative aeroplanes
Institution: Royal Aeronautical Society (RAeS)
Date: December 14
Type: Draft
Number of Pages: 11
Keywords: aeromodel, flight test data

*****

Reference Type: Conference Proceedings
Author: Royal Aeronautical Society (RAeS)
Year of Conference: 1996
Title: Proceedings of Training: Lowering the Cost, Maintaining the Fidelity Conference
Conference Name: Training: Lowering the Cost, Maintaining the Fidelity
Conference Location: London
Publisher: Royal Aeronautical Society (RAeS)
Date: May 15-16
Number of Pages: 2

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Reference Type: Conference Paper
Author: Royal Aeronautical Society (RAeS)
Year: 1996
Title: Proposal for use of engineering simulator data as a supplement to flight test data to support flight simulator qualification for modified or derivative aeroplanes
Conference Name: Flight Simulation Data Conference
Conference Location: London
Publisher: Royal Aeronautical Society (RAeS)
Date: May 17
Number of Pages: 15

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Reference Type: Conference Proceedings
Author: Royal Aeronautical Society (RAeS)
Year of Conference: 2000
Title: Proceedings of RAeS Flight Simulation--The Next Decade
Conference Name: Flight Simulation--The Next Decade
Conference Location: London, UK
Publisher: RAeS
Date: May 10-12
Notes: <u>Contents:</u>
Keeping Simulators in Pace with a Fourth Generation Fighter Aircraft (by S. Sandberg, Saab Aerospace, Sweden)
Interactive Hybrid Environment Training (by Sqn. Ldr. J. Sullivan, Ministry of Defence, UK)
Applications and Future Trends in Synthetic Environments for Military Training Systems (by Dr. P. Howells and D. Siksik, CAE Electronics, Canada)
Ab-Initio Simulation in the 21st Century (by Capt. S. Green, BAE SYSTEMS Flight Training (Europe), Spain)
Flight Crew Training Needs for the Future (by Capt. J. Pugh and Capt. S. Wood, Virgin Atlantic Airways, UK)
The Instructor/Operator Station - Where Do We Go From Here? (by V. Faconti, The Boeing Company, USA)
MSHATF - Delivering Military Helicopter Training in the New Millennium (by B. Symes, CAE Aircrew Training Services, UK)
Aviation Instruction through Flight Simulation: Enhancing Pilot Decision-Making Skills (by Dr. M. Green, Embry-Riddle Aeronautical University, USA)
The Future and Technology of Remote Training: "Bringing Training to the Pilot" (by Dr. D. White, Thomson Training & Simulation, UK)
The Role of the Regulator (by D. Otto, Joint Aviation Authorities, The Netherlands and D. Irving, Civil Aviation Authority, UK)
Is Today's Flight Simulator Prepared for Tomorrow's Requirements? (by P. Ray, Federal Aviation Administration, USA)
The Importance of Matching Technology Advancement With Training Needs (by Capt. K. Caudrey, Flight Safety Boeing Trading International, Canada)
Developments in Data Communications and their Effect on Simulation (by P. Brash, Thomson Training and Simulation, UK)
Improving the Value of Commercial Training Simulators: Key Concerns and the Search for Resolution (by R. Curnutt and K. Neville, Boeing Commercial Airplane Group, USA)
Predictive Models for Aerial Refueling Simulations (by C. Svoboda and G. Ryan III, Kohlman Systems Research, USA)
PC Simulators: Don't Call Them Games Anymore (by G. Pisanich, Jane's Combat Simulations/Electronic Arts, USA)
Simulator Fidelity - The Effect of Platform Motion (by Dr. J. Bürki-Cohen, US Department of Transportation, E. Boothe and Dr. N. Soja, Consultants, Dr. R. Disario, Bryant College, Dr. T. Go, Massachusetts Institute of Technology, and Dr. T. Longridge, Federal Aviation Administration, USA)

Integrated Motion Cueing Algorithm and Motion-Based Design for Flight Simulators (by Dr. S. Advani, Aircraft Development and Systems Engineering, and Dr. R. Hosman, Aerospace Man-Machine Systems Consulting, The Netherlands)
The "All Digital Display" (by P. Berwick, SEOS Displays Ltd., UK)
Future Visual Systems Technology (by A. Fernie, CAE Electronics, Canada)
Systems and Research in Networked Tactical Training (by Dr. R. Kruk, CAE Electronics, Canada, Dr. D. Wightman and Dr. W. Howse, US Army Research Institute, USA)
Distributed Simulation Using COTS Software and Commodity Hardware (by A. Jenkins and F. Lambert, Boeing Commercial Airplane Group, USA)
Network Enabled Image Generators in DIS and HLA Environment (by L. Call, Air Force Research Laboratory, USA)
Collective Training - Virtually a Reality or Still Over the Horizon (by A. Aylward, Thomson Training and Simulation, UK)

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Reference Type: Unpublished Work
Author: Royal Aeronautical Society (RAeS)
Year: 2002
Title of Work: Flight Simulation Group position paper: Flight simulation
Number: Sept. 6
Date: March 5, 2002
Abstract: This paper is intended as a briefing document summarizing the advantages and uses of flight simulation, describing some of the current technology available, indicating how and why it works, and summarizing the current national and international regulatory framework.
Notes: As of 2/05/07, the web site was no longer accessible.
URL: http://www.raes.org.uk/fl-sim/FSG%20Position%20Paper.htm

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Reference Type: Conference Proceedings
Author: Roza, Manfred; Wentink, Mark; Feenstra, Philippus
Year of Conference: 2007
Title: Performance testing of the Desdemona motion system
Conference Name: AIAA Modeling and Simulation Technologies Conference and Exhibit
Conference Location: Hilton Head, SC
Publisher: American Institute of Aeronautics and Astronautics (AIAA)
Date: August 20-23
Electronic Resource Number: AIAA 2007-6472
Author's Title and Affiliation: Research Scientists, TNO Human Factors, Soesterberg, The Netherlands
Abstract: In the spring of 2007 TNO Human Factors together with AMST Systemtechnik GmbH have completed the development of their newest research simulator, the Desdemona, in the Netherlands. The Desdemona research simulator features a unique motion system not seen elsewhere in the world. Its serial design and geometrical dimensions give the motion system a large cylindrical motion space and a broad range of dynamic performance capabilities, which go beyond those of a classical Stewart platform. Like any other motion-base simulator the Desdemona motion system is driven by motion filters that transform the various simulation model outputs into safe and optimal motion cues. For the development of these motion filters it is necessary to exactly determine the dynamic performance characteristics of Desdemona and check whether these characteristics meet the specified motion system requirements. This paper describes the test protocol to measure, specify and verify the dynamic performance characteristics of the Desdemona motion system. The performance test protocol builds upon and extends the classical synergistic motion test approaches, like the AGARD standard, to suit the specific Desdemona motion system capabilities.
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Reference Type: Presentation
Author: Rupert, Angus; Clark, Jonathan; Oman, Charles
Year: 2007
Title: Astronaut selection & training to optimize maintenance of spatial orientation
Presentation Event: 2007 Symposium on the Role of the Vestibular Organs in Space Exploration
Event Location: The Netherlands
Date: June 7-9
Author's Title and Affiliation: Angus Rupert: Naval Aerospace Medical Research Laboratory (NAMRL), Pensacola, FL
Jonathan Clark: National Space Biomedical Research Institute (NSBRI), Houston, TX
Charles Oman: Massachusetts Institute of Technology (MIT), Cambridge, MA
Keywords: spatial orientation, upset recovery training (URT)
Abstract: Outline:
- First Astronaut Fatality in Space 1967
  - NASA mishap board recommendations
- Astronaut Training/Diagnostic Devices
- Navy/DoD Experiences
- Vestibular Test Battery

Notes: URL is no longer working (9/30/09).
URL:
http://www.congrex.nl/06a07/presentations/session%2005%20Spaceflight%20Countermeasures/05_03_Rupert.pdf

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Reference Type: Report
Author: Ryan, L. E.; Scott, P. G.; Browning, R. F.
Year: 1978
Title: The effects of simulator landing practice and the contribution of motion simulation to P-3 pilot training
City: Orlando, FL
Institution: Navy Training Analysis and Evaluation Group
Date: September
Report Number: TAEG Report No. 63
Number of Pages: 39

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Reference Type: Conference Paper
Author: Sabourin, Marc-Olivier; Sondermeyer, Vincent
Year: 2000
Title: G-cueing for fighter simulation training
Conference Name: Modeling and Simulation Technologies Conference and Exhibit
Conference Location: Denver, CO
Publisher: American Institute of Aeronautics and Astronautics (AIAA)
Date: August 14-17
Electronic Resource Number: AIAA-2000-4073
Author's Title and Affiliation: CAE, Montreal, Canada
Number of Pages: 9
Abstract: An operator can be regarded as a set of sensors with a feedback algorithm (reflexes and skills), rules, and a knowledge base that are used in stabilizing and controlling an aircraft in a given flight path. Motion cueing devices play a role in the training tool by enabling the trainee to develop proper control strategy (tuning the gains of the feedback algorithm), and to acquire parts of the required set of rules and knowledge base (by simulating representative workload, for example). The motion system and the g-seat both have relative advantages and disadvantages and the choice of one, the other, or both must be made on the basis of an optimal alignment between the training objectives and the capabilities of the training device. This paper will describe an optimized g-cueing seat design and compare its training potential with a standard Stewart motion platform by evaluating their respective effects on the pilot control loop, on the required workload and on their effectiveness in facilitating the training of rule-based and knowledge-based behaviors.

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Reference Type: Edited Book
Editor: Salas, Eduardo; Bowers, Clint A.; Prince, Carolyn (Guest Eds.)
Year: 1998
Title: Simulation and training in aviation
Series Editor: Jensen, Richard S.
Series Title: International Journal of Aviation Psychology (IJAP) - Special Issue
City: Mahwah, NJ
Publisher: Lawrence Erlbaum Associates
Volume: 8 (3)
Author's Title and Affiliation: Salas: Naval Air Warfare Center Training Systems Division, Orlando, FL
Bowers: Department of Psychology, University of Central Florida, Orlando, FL
Prince: Naval Air Warfare Center Training Systems Division, Orlando, FL
Abstract: [Preface] Aviation relies heavily on the use of simulation to train pilots. Over the past 50 years, we have witnessed tremendous changes in the simulations as well as the simulators that are being used in aviation training. We have also witnessed an explosion in training research, especially in aviation. Therefore, the field is now in a position to examine the role of simulation in training and ask: How can simulation optimize learning and skill acquisition in aviation environments? Collectively, the articles in this special issue critically examine the current status of simulation and its implications for training.
The first article by Salas, Bowers, and Rhodenizer discusses some existing assumptions that exist concerning the use of simulation in aviation training. Salas et al. suggest that the aviation industry may not be using simulation most optimally to enhance training outcomes. Consequently, they challenge behavioral scientists and simulator developers to bridge the gap between research and application. Fowlkes, Dwyer, Oser, and Salas suggest a technique for simulation training that aids in bridging the gap between training research and industry practice. They describe an approach to the design of simulation exercises that methodically links training objectives, exercise design, and performance assessment. Additionally, they offer evidence for effectiveness of this approach and additional contexts in which it can be applied. In a similar vein, Bell and Waag review the existing literature on the effectiveness of simulation training for combat skills. Bell and Waag suggest that present evaluation techniques are inadequate and propose a new model for conducting simulation training evaluations.
Three articles address the use of low-fidelity computer-based simulations for training. The article by Jentsch and Bowers addresses a common concern with the use of low-fidelity simulation in training--the

validity of low-fidelity simulation. These authors cite empirical evidence that demonstrates that low-fidelity simulation is content and construct valid for training aircrew coordination. Dennis and Harris provide an empirical investigation into the use of low-fidelity, desktop, computer-based simulation to train novice pilots. Their research indicates that this level of simulation is beneficial for training ab initio pilots. Dennis and Harris conclude that the benefits from this level of simulation are more likely to be cognitive rather than psychomotor. Koonce and Bramble also discuss the role of personal computer-based training devices by focusing on topics such as ab initio training, transfer, and the certification of these devices in flight programs.
The final article by Bürki-Cohen, Soja, and Longridge provides a review of the issues related to the use of high-fidelity simulation. These authors provide an in-depth look into the use of motion-based simulation in pilot training and qualification programs.
The editors, along with the authors, thank the many reviewers who participated in the publication process. Their comments were invaluable to improving the quality of each of these articles. Our hope is that this special issue will generate the necessary dialogue between scientists, engineers, and policymakers about the way we currently apply simulation for aviation training.
Notes: Contents:
Preface:
Special issue on Simulation and Training in Aviation (by E. Salas, C.A. Bowers, and C. Prince)
Formal Papers:
It Is Not How Much You Have but How You Use It: Toward a Rational Use of Simulation to Support Aviation Training (by E. Salas, C.A. Bowers, and L. Rhodenizer)
Event-Based Approach to Training (EBAT) (by J. Fowlkes, D.J. Dwyer, R.L. Oser, and E. Salas)
Evaluating the Effectiveness of Flight Simulators for Training Combat Skills: A Review (by H.H. Bell and W.L. Waag)
Evidence for the Validity of PC-Based Simulations in Studying Aircrew Coordination (by F. Jentsch and C.A. Bowers)
Computer-Based Simulations as an Adjunct to Ab Initio Flight Training (by K.A. Davis and D. Harris)
Personal Computer-Based Flight Training Devices (by J.M. Koonce and W.J. Bramble, Jr.)
Simulator Platform Motion - The Need Revisited (by J. Bürki-Cohen, N. Soja, and T. Longridge)

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Reference Type: Journal Article
Author: Salas, Eduardo; Bowers, Clint A.; Rhodenizer, Lori
Year: 1998
Title: It is not how much you have but how you use it: Toward a rational use of simulation to support aviation training
Journal: International Journal of Aviation Psychology (IJAP)
Volume: 8
Issue: 3
Pages: 197-208
Author's Title and Affiliation: Salas: Naval Air Warfare Center Training Systems Division, Orlando, FL
Bowers, Rhodenizer: Department of Psychology, University of Central Florida, Orlando, FL
Number of Pages: 12
Keywords: simulation use, aviation training, overreliance on high-fidelity simulation, misuse of simulation
Abstract: One of the most remarkable changes in aviation training over the past few decades is the use of simulation. The capabilities now offered by simulation have created unlimited opportunities for aviation training. In fact, aviation training is now more realistic, safe, cost-effective, and flexible than ever before. However, we believe that a number of misconceptions--or invalid assumptions--exist in the simulation community that prevent us from fully exploiting and utilizing recent scientific advances in a number of related fields in order to further enhance aviation training. These assumptions relate to the overreliance on high-fidelity simulation and to the misuse of simulation to enhance learning of complex skills. The purpose of this article is to discuss these assumptions in the hope of initiating a dialogue between behavioral scientists and engineers.

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Reference Type: Journal Article
Author: Saleem, Jason J.; Kleiner, Brian M.
Year: 2006
Title: A case-based review of critical incidents in general aviation for improved safety
Journal: International Journal of Applied Aviation Studies
Volume: 6
Issue: 2
Pages: 271-282
Number of Pages: 12
Abstract: We report on critical incidents in which pilot error occurred during field observations of landing approaches to a mid-sized, controlled airport. These occurrences included a case where a hand-off of air traffic control (ATC) from the airport approach to airport tower was delayed by the pilot, a case where the pilot requested an incorrect runway for a practice instrument approach, and a case where a pilot missed a course correction command from ATC. Each of these cases involves communications errors, where information exchanged from ATC to the pilot was not initially processed by the pilot or the information exchanged was incorrect. We use these cases to demonstrate how modest, pilot-focused design enhancements to the GA human-machine system may help minimize the occurrence of similar errors.

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Reference Type: Report
Author: Sallee, G. P.; Gibbons, D. M.
Year: 1998
Title: AIA/AECMA project report on Propulsion System Malfunction plus Inappropriate Crew Response (PSM + ICR)
Date: November 1
Type: 2 Volumes of Project Report
Author's Title and Affiliation: Salle: AIA Co-Chair
Gibbons: AECMA Co-Chair
Number of Pages: Volume 1: 82
Volume 2: 179

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Reference Type: Conference Paper
Author: Sandburg, Stefan
Year: 2000
Title: Keeping simulators in pace with a fourth generation fighter aircraft
Conference Name: Flight Simulation - The Next Decade
Conference Location: London, UK
Publisher: Royal Aeronautical Society (RAeS)
Date: May 10-12
Author's Title and Affiliation: Saab Aerospace, Linköping, Sweden
Number of Pages: 4
Abstract: The challenge to keep a flight-training simulator in pace with the technological advances in the aircraft has proven to be a time and resource consuming exercise and has not always been met with success. It is a known fact to the flight simulator community that flight simulators lagging behind the aircraft standard are more common than one would expect knowing that the trainers provide a safer and more cost efficient way of training pilots. Experience shows that the available budget for a weapon system upgrade is spent on the weapon system itself rather than on its training system.
The absolute requirement from the end user of the aircraft system is that the flight simulators should be modified, validated and commissioned in time to meet the training requirement. This normally means that the simulators should be available for training at the same time or earlier than the arrival of the modified aircraft. A desirable requirement would be to have the simulator to support the flight test, evaluation and the development of new training programs and tactics that are performed by the contractor and the customer prior to the introduction to the operational squadron. In the Swedish Air Force Saab Viggen

program this objective has successfully been met through the adaptation of the development process to support the flight-training simulator.

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Reference Type: Presentation
Author: Sanderson, Jeff; Kalsey, Jas; Oman, Charles; Harris, Laurence
Year: 2006
Title: Measuring and attenuating head-movement and induced oscillopsia
Presentation Event: 7th Symposium on the Role of the Vestibular Organs in Space Exploration
Event Location: The Netherlands
Date: June 7-9
Type: Poster
Author's Title and Affiliation: Jeff Sanderson, Jas Kalsey, Laurence Harris: Center for Vision Research, York University, Toronto, Canada
Charles Oman: Man-Vehicle Laboratory, Massachusetts Institute of Technology, Cambridge, MA
Keywords: oscillopsia, upset recovery training (URT)
Abstract: Head movement contingent oscillopsia is commonly reported by astronauts during entry, landing, and for several days post flight, but methods for directly quantifying it have been lacking. Oscillopsia is characterized by the sensation that objects in the visual field are moving. Here we use vestibular Coriolis stimulation as a model of head-movement contingent oscillopsia and measure its temporal duration by the method of cancellation.
Notes: URL is no longer working (9/30/09).
URL: http://www.congrex.nl/06a07/presentations/session%20posters/P08_Sanderson.pdf

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Reference Type: Journal Article
Author: Sattler, D. E.; Sinclair, M.; Kereliuk, S.
Year: 1980
Title: An investigation of the recovery from an engine failure in a twin engine augmentor wing aircraft using the NAE Airborne Simulator
Journal: Canadian Aeronautics and Space Journal
Pages: 26-40
Author's Title and Affiliation: National Aeronautical Establishment
Number of Pages: 15
Abstract: A brief piloted simulation program was conducted using the NAE Airborne Simulator to investigate the airworthiness aspects of a twin engine augmentor wing aircraft experiencing an engine failure during final approach. Three evaluation pilots flew a series of STOL approaches (-7.5 degree glideslope to a 4000 ft runway) consisting of normal two engine approaches and approaches on which an engine was failed at a height ranging from 17 to 92 ft above the runway elevation. Quantitative and qualitative flight evaluation data were collected illustrating that acceptable touchdown sink rates could be achieved following an engine failure at any point on the approach, provided that adequate pilot warning systems and automatic thrust compensation systems were available, and that correct pilot recovery technique was employed.

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Reference Type: Report
Author: Scanlon, Charles H.
Year: 1987
Title: Effect of motion cues during complex curved approach and landing tasks
Pages: 1-24
Date: December
Type: NASA Technical Paper
Report Number: NASA TP-2773

Author's Title and Affiliation: Arkansas State University, AR
Number of Pages: 27
Keywords: simulator motion, workload, complex approach paths
Abstract: A piloted simulation study was conducted to examine the effect of motion cues using a high-fidelity simulation of a commercial airplane during the performance of complex curved approach and landing tasks in the signal environment of the microwave landing system (MLS). The data from these tests indicate that in a high-complexity MLS approach task with moderate turbulence and wind, the pilot uses motion cues to improve path tracking performance. No significant differences in tracking accuracy were noted for the low- and medium-complexity tasks, regardless of the presence of motion cues. Higher control-input rates were measured for all the tasks when motion was used. Pilot eye scan, as measured by instrument dwell time, was faster when motion cues were used regardless of the complexity of the approach tasks. A pilot subjective rating, based on time, mental effort, and psychological stress loads, yielded larger work load ratings with motion than with no motion. Pilot comments indicated a preference for motion. With motion cues, pilots appeared to work harder in all levels of task complexity and to improve tracking performance in the most complex approach task.

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Reference Type: Magazine Article
Author: Scerbo, M. W.
Year: 2005
Title: Medical virtual reality simulators: Have we missed an opportunity?
Magazine: Human Factors and Ergonomics Society (HFES) Bulletin
Volume: 48
Issue Number: 5
Pages: 1-3
Date: May
Type of Article: online news bulletin
Number of Pages: 4
Abstract: (taken from introduction) Interest in simulators for training has a long history within the human factors profession. In fact, articles addressing driving simulation and simulated displays for vigilance monitoring began appearing in the pages of Human Factors in the early 1960s. Since then, more than 400 articles on simulation topics such as flight, air traffic control, command and control, driving, power plant operation, and simulator networking have appeared in Human Factors, Ergonomics in Design, and the annual meeting proceedings (see also Swezey & Andrews, 2001). In the early 1970s, interest in medical issues also began to be reflected in the pages of Human Factors. A formal technical group called Medical Systems and Rehabilitation was formed in 1992 (now called the Health Care Technical Group). Today, more than 100 articles can be found in our literature addressing diagnoses, medical devices, errors, procedures, and patient safety.
URL: http://www.hfes.org/web/BulletinPdf/bulletin0505.pdf

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Reference Type: Journal Article
Author: Schmerler, J.
Year: 1976
Title: The visual perception of accelerated motion
Journal: Perception
Volume: 5
Issue: 2
Pages: 167-185
Author's Title and Affiliation: Department of Social Science, Fordham University, Lincoln Center Campus, New York 10023
Number of Pages: 19
Abstract: The present research is an investigation of how changes in the rate of motion are perceived. Five separate experiments were performed with the use of filmed stimulus material and a variety of

response measures, including both categorical judgments and reproduction techniques. It was found that (a) the smaller the ratio of terminal to initial velocity, the less frequent the judgments of acceleration or deceleration, (b) deceleration was significantly easier to perceive than acceleration, (c) the perception of acceleration was facilitated when the velocity of a lead-in segment was the same as the velocity at onset of motion, (d) a short tunnel centered in the motion path facilitated the perception of acceleration and deceleration, and (e) instantaneous changes in velocity were much more easily perceived than gradual changes. A one-event model for the perception of motion change in which there is a continuous interplay between earlier, later, and interpolated motion segments is favored over a two-event model in which earlier and later segments of velocity are compared.

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Reference Type: Journal Article
Author: Schmidt, David K.; Raney, David L.
Year: 2001
Title: Modeling and simulation of flexible flight vehicles
Journal: Journal of Guidance, Control, and Dynamics
Volume: 24
Issue: 3
Pages: 539-546
Date: May-June
Original Publication: Presented as Paper 98-4359 at AIAA Modeling and Simulation Technologies Conference, Boston, MA, August 10-12 1998.
Author's Title and Affiliation: Schmidt: Professor and Director, Flight Dynamics and Control Laboratory, University of Colorado at Colorado Springs
Raney: Aerospace Engineer, Dynamics and Control Branch, NASA Langley Research Center
Number of Pages: 8
Abstract: The effects of flexibility on the flight dynamics of large aircraft have been shown to be quite significant, especially as the frequencies of the elastic modes become lower and approach those of the rigid-body modes. The handling characteristics of such vehicles are altered significantly from those of a rigid vehicle, and the design of the flight-control system may become drastically more complex. Consequently, the need to model accurately the dynamics of such vehicles, and to develop valid simulations, is becoming particularly acute. The theoretical development of a generic flexible-aircraft model is reviewed. This modeling technique allows for the flexible degrees of freedom to be added to an existing simulation model of the vehicle's rigid-body dynamics. The data necessary for modeling a specific vehicle include aerodynamic stability derivatives, aerodynamic influence coefficients, elastic mode shapes, modal frequencies and damping, and generalized masses. Two case studies are presented, both involving the development of motion-based simulations in NASA Langley Research Center's simulation facility. The first example investigates an aircraft similar in geometry to the B-1, whereas the second investigates a large highspeed commercial transport. The dynamic responses (time and frequency domain) for these vehicles are presented, along with the evaluations of the effects of dynamic aeroelasticity on their handling characteristics. The vehicle responses are critical to evaluating hardware and software requirements for simulation fidelity, for example, visual and motion cues. Finally, a brief assessment of the effects of limitations of the simulation facility is presented. Limitations considered include digital time delay, motion hardware bandwidth, and motion washout logic.
Author Address: Schmidt: University of Colorado at Colorodo Springs, Colorado Springs, CO, 80918
Raney: NASA Ames Research Center, Hampton, VA 23681

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Reference Type: Report
Author: Schmidt, Stanley F.; Conrad, Bjorn
Year: 1970
Title: Motion drive signals for piloted flight simulators
City: Palo Alto, CA
Institution: National Aeronautics and Space Administration (NASA)
Report Number: NASA CR-1601
Author's Title and Affiliation: NASA Ames Research Center
Number of Pages: 75
Abstract: An important aspect of many piloted flight simulators is their ability to provide realistic motion cues. Since such simulators are constrained to move within the confines of their mechanical drive systems, they cannot duplicate all motions (and hence all the motion cues) associated with a real aircraft. In order to use the limited motion capabilities of a simulator effectively it is thus necessary to a) determine which motion cues are important to a pilot; b) ascertain which cues are attainable within the drive system capabilities of a simulator; c) synthesize logic for commanding motion achievable by the drive system and realistic to a pilot. This report summarizes a mathematical approach to this problem and presents logic synthesized for the Ames All-Axis Motion Generator. Both the theory developed and the logic presented should be applicable to a wide variety of motion simulation problems.

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Reference Type: Journal Article
Author: Schrater, Paul R.; Knill, Davil C.; Simoncelli, Eero P.
Year: 2000
Title: Mechanisms of visual motion detection
Journal: Nature Neuroscience
Volume: 3
Pages: 64-68
Author's Title and Affiliation: Schrater: Department of Psychology, University of Minnesota, N218 Elliott Hall, 75 E. River Dr., Minneapolis, Minnesota 55455, USA
Knill: Department of Psychology, University of Pennsylvania, 3815 Walnut St., Philadelphia, Pennsylvania 19104, USA
Simoncelli: Center for Neural Science, New York University, 4 Washington Place, New York, New York 10003, USA
Abstract: Visual motion is processed by neurons in [the] primary visual cortex that are sensitive to spatial orientation and speed. Many models of local velocity computation are based on a second stage that pools the outputs of first-stage neurons selective for different orientations, but the nature of this pooling remains controversial. In a human psychophysical detection experiment, we found near-perfect summation of image energy when it was distributed uniformly across all orientations, but poor summation when it was concentrated in specific orientation bands. The data are consistent with a model that integrates uniformly over all orientations, even when this strategy is sub-optimal.
Author Address: schrater@eye.psych.umn.edu

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Reference Type: Journal Article
Author: Schroeder, Chris; Harms, Dieter
Year: 2007
Title: MPL represents a state-of-the-art ab initio airline pilot training programme
Journal: ICAO Journal
Volume: 62
Issue: 3
Pages: 15-16, 31-32
Author's Title and Affiliation: International Air Transport Association (IATA)
Number of Pages: 4
Keywords: multi-crew pilot license (MPL)

Abstract: The newly established multi-crew pilot licence is focused from Day One on preparing the co-pilot candidate for the right seat of an advanced airliner, using a competency-based approach to training developed with an emphasis on improving flight deck safety.

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Reference Type: Conference Proceedings
Author: Schroeder, Jeffery; Chung, William; Tran, Duc; Laforce, Soren
Year of Conference: 1998
Title: Pilot-induced oscillation prediction with three levels of simulation motion displacement
Conference Name: AIAA Atmospheric Flight Mechanics Conference and Exhibit
Conference Location: Boston, MA
Publisher: American Institute of Aeronautics and Astronautics (AIAA)
Volume: Collection of Technical Papers (A98-37204 10-08)
Pages: 1-11
Date: August 10-12
Electronic Resource Number: AIAA-1998-4333
Author's Title and Affiliation: Schroeder, Chung, Tran: NASA Ames Research Center, Moffett Field, CA
Laforce: SYRE Logicon, Moffett Field, CA
Number of Pages: 11
Abstract: Simulator motion platform characteristics were examined to determine if the amount of motion affects pilot-induced oscillation (PIO) prediction. Five test pilots evaluated how susceptible 18 different sets of pitch dynamics were to PIOs with three different levels of simulation motion platform displacement: large, small, and none. The pitch dynamics were those of a previous in-flight experiment, some of which elicited PIOs. These in-flight results served as truth data for the simulation. As such, the in-flight experiment was replicated as much as possible. Objective and subjective data were collected and analyzed. With large motion, PIO and handling qualities ratings matched the flight data more closely than did small motion or no motion. Also, regardless of the aircraft dynamics, large motion increased pilot confidence in assigning handling qualities ratings, reduced safety pilot trips, and lowered touchdown velocities. While both large and small motion provided a pitch rate cue of high fidelity, only large motion presented the pilot with a high fidelity vertical acceleration cue.

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Reference Type: Conference Paper
Author: Schroeder, Jeffrey; Chung, William W. Y.; Hess, Ronald A.
Year: 1999
Title: Spatial frequency and platform motion effects on helicopter altitude control
Conference Name: Modeling and Simulation Technologies Conference and Exhibit
Conference Location: Portland, OR
Publisher: American Institute of Aeronautics and Astronautics (AIAA)
Date: August 9-11
Electronic Resource Number: AIAA-1999-4113
Author's Title and Affiliation: Schroeder: NASA Ames Research Center, Moffett Field, CA
Chung: Logicon Information Systems & Services, Moffett Field, CA
Hess: University of California, Davis, CA
Number of Pages: 11
Abstract: An experiment examined how visual scene and platform motion variations affected a pilot's ability to perform altitude changes. Pilots controlled a helicopter model in the vertical axis and moved between two points 32-ft apart in a specified time. Four factors were varied: visual scene spatial frequency, visual scene background, motion filter gain, and motion filter natural frequency. Drawing alternating black and white stripes of varying widths between the two extreme altitude points varied visual scene spatial frequency. Visual scene background varied by either drawing the stripes to fill the entire field-of-view or by placing the stripes on a narrow pole with a natural sky and ground plane behind the pole. Both the motion filter gain and natural frequency were varied in the motion platform command

software. Five pilots evaluated all combinations of the visual and motion variations. The results showed that only the motion filter natural frequency and visual scene background affected pilot performance and their subjective ratings. No significant effects of spatial frequency or motion system gain found for the values examined in this tracking task. A previous motion fidelity criterion was found to still be a reasonable predictor of motion fidelity.

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Reference Type: Conference Proceedings
Author: Schroeder, Jeffery A.
Year of Conference: 1993
Title: Simulation motion effects on single axis compensatory tracking
Conference Name: AIAA Flight Simulation Technologies Conference
Conference Location: Monterey, CA
Publisher: American Institute of Aeronautics and Astronautics (AIAA)
Date: August
Electronic Resource Number: AIAA-93-3579-CP
Author's Title and Affiliation: Aerospace Engineer, NASA Ames Research Center
Abstract: An experiment that examined how changes in a motion platform drive filter affect pilot-vehicle performance and opinion was conducted on the NASA Ames Vertical Motion Simulator. Pilots controlled a simplified helicopter model in the vertical or the directional axis and tracked a randomly moving target aircraft in the presence of a random disturbance. With both tasks, variations from full motion to fixed-based conditions were made in high-pass drive filter gain and natural frequency. The results indicate that vertical motion did not affect the open-loop pilot-vehicle target-tracking crossover frequency, but target-tracking phase margins improved with increased filter gain or decreased natural frequency. Vertical disturbance-rejection crossover frequency increased with decreasing filter natural frequency, while disturbance rejection phase margins improved with increasing filter gain. Vertical tracking errors increased significantly when all vertical motion was removed. No significant differences were measured among the directional configurations, which indicates that pure yaw motion cues may not be as important as previously thought in flight simulation.
Author Address: NASA Ames Research Center, Moffett Field, CA

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Reference Type: Journal Article
Author: Schroeder, Jeffery A.
Year: 1996
Title: Evaluation of simulation motion fidelity criteria in the vertical and directional axes
Journal: Journal of the American Helicopter Society
Pages: 44-57
Date: February
Author's Title and Affiliation: Aerospace Engineer, NASA Ames Research Center, Moffett Field, CA
Number of Pages: 14
Abstract: An evaluation of existing motion fidelity criteria was conducted on the NASA Ames Vertical Motion Simulator. Experienced test pilots performed single-axis repositioning tasks in both the vertical and the directional axes using transfer-function approximations of a hovering helicopter. Gain and natural frequency variations were made only in the software filters that attenuate the commands to the simulator motion system. The variations spanned motion response characteristics from nearly full math-model motion to fixed-base. Between configurations, pilots recalibrated their motion response perception by flying the task with full motion. Pilots subjectively rated the motion fidelity of subsequent configurations relative to this full motion base, which was considered the standard for comparison. The results suggested that the existing vertical-axis criterion was accurate for combination of gain and natural frequency changes. However, if only the gain or the natural frequency was changed, the rated motion fidelity was better than the criterion predicted. In the vertical axis, the objective and subjective results indicated that a larger gain reduction was tolerated than the existing criterion allowed. Significant degradations in performance were noted between the full-vertical motion and no-vertical motion

configurations. The limited data collected in the yaw axis revealed that pilots had difficulty in distinguishing among the variations in the pure yaw motion cues, thus indicating that pure yaw motion may be of little importance in hovering flight simulation.

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Reference Type: Report
Author: Schroeder, Jeffery Allyn
Year: 1999
Title: Helicopter flight simulation motion platform requirements
Date: July
Report Number: Organization report number: A-9900432
Sponsor's report number: NASA/TP-1999-208766
Author's Title and Affiliation: Schroeder: NASA Ames Research Center, Moffett Field, CA
Number of Pages: 84
Keywords: flight simulation, helicopters, motion platforms
Abstract: To determine motion fidelity requirements, a series of piloted simulations was performed. Several key results were found. First, lateral and vertical translational platform cues had significant effects on fidelity. Their presence improved performance and reduced pilot workload. Second, yaw and roll rotational platform cues were not as important as the translational platform cues. In particular, the yaw rotational motion platform cue did not appear at all useful in improving performance or reducing workload. Third, when the lateral translational platform cue was combined with visual yaw rotational cues, pilots believed the platform was rotating when it was not. Thus, simulator systems can be made more efficient by proper combination of platform and visual cues. Fourth, motion fidelity specifications were revised that now provide simulator users with a better prediction of motion fidelity based upon the frequency responses of their motion control laws. Fifth, vertical platform motion affected pilot estimates of steady-state altitude during altitude repositionings. Finally, the combined results led to a general method for configuring helicopter motion systems and for developing simulator tasks that more likely represent actual flight. The overall results can serve as a guide to future simulator designers and to today's operators.

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Reference Type: Conference Paper
Author: Schroeder, Jeffery A.; Chung, William W.; Laforce, Soren
Year: 1997
Title: Effects of roll and lateral flight simulation motion gains on a sidestep task
Conference Name: American Helicopter Society 53rd Annual Forum
Conference Location: Virginia Beach, VA
Date: April 29-May 1
Abstract: To represent coordinated maneuvers accurately in a ground-based flight simulator, the motion platform must translate laterally when it rolls. Typical platform lateral displacement limits often prevent an accurate representation of such maneuvers. The result is that the pilot receives an uncoordinated lateral specific force (ball not centered) when the model is not calculating one. This study examined the effects of these false uncoordinated roll-lateral motion cues when using a coordinated math model. The vehicle model represented a typical helicopter with satisfactory handling qualities in the roll-lateral axes. The task was a two-degree-of-freedom sidestep, in which the pilot controlled lateral position through roll attitude. Two gains varied in the motion platform control. One gain controlled the ratio between platform roll angle and math model (and thus visual) roll angle. The other gain controlled the amount of lateral platform movement, relative to the amount needed, to keep the apparent gravity vector aligned vertically about the pilot. Both gains varied from zero to one. With both gains equal to one, pilots evaluated the true 1:1 motion case, in which the motion cues matched the visual cues. As the motion cues degraded, both objective and subjective evaluations worsened. Pilot opinions of motion fidelity reasonably matched a combination of criteria developed previously.

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Reference Type: Conference Paper
Author: Schroeder, J. A.; Johnson, W. W.
Year: 1995
Title: Yaw motion cues in helicopter simulation
Conference Name: AGARD FVP Symposium on "Flight Simulation -- Where are the Challenges?"
Conference Location: Braunschweig, Germany
Publisher: Advisory Group for Aerospace Research and Development (AGARD)
Date: May 22-25
Author's Title and Affiliation: NASA Ames Research Center, Mail Stop 262-3, Moffett Field, CA
Abstract: 1. SUMMARY
A piloted simulation that looked at the effects of yaw motion cues on pilot-vehicle performance, pilot workload, and pilot motion perception was conducted on the NASA Ames Vertical Motion Simulator. The vehicle model that was used represented an AH-64 helicopter. Three tasks were performed in which only combinations of vehicle yaw and vertical displacement were allowed. The commands issued to the motion platform were modified to present the following four motion configurations for a pilot located forward of the center of rotation: 1) only the linear translations, 2) only the angular rotation, 3) both the linear translations and the angular rotations, and 4) no motion. The objective data indicated that pilot-vehicle performance was reduced and the necessary control activity increased when linear motion was removed; however, the lack of angular motion did not result in a measured degradation for almost all cases. Also, pilots provided subjective assessments of their compensation required, the motion fidelity, and their judgment of whether or not linear or rotational cockpit motion was present. Ratings of compensation and fidelity were affected by linear acceleration, and the rotational motion had no significant impact. Also, when only linear motion was present, pilots typically reported the presence of rotation. Thus, linear acceleration cues, not yaw rotational cues, appear necessary to simulate hovering flight.

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Reference Type: Conference Proceedings
Author: Schweikhard, W. G.; Platz, S. J.; Halverstadt, D. E.; Landis, Darin; Bounajem, Elias
Year of Conference: 1990
Title: Flight test data processing, plotting and analysis at your finger tips--A flexible, automated, integrated approach
Conference Name: AIAA/SFTE/DGLR/SETP Fifth Biannual Flight Test Conference
Conference Location: Ontario, Canada
Pages: 1-13
Date: May 22-24
Electronic Resource Number: AIAA-1990-1322
Author's Title and Affiliation: Kohlman Systems Research (KSR), Lawrence, KS
Abstract: Modern flight test data acquisition systems do not put the data where it is needed, namely in the hands of the analysis engineer who is charged with producing the final report. Those that do, do not provide the analysis engineers the flexible versatile software that allows them to operate on it in the way they want. The Flight Test Applications Software Package (FTASP) is an example of the sort of software that is needed for accessing today's huge data bases, breaking them down to a size that is usable by the analysis engineer and providing all of the tools needed to operate on the data and prepare the final report. FTASP specifically addresses the analysis of aircraft performance, stability and control, but this is only a sample. The concept can be easily appended to accommodate the flight test disciplines of propulsion, loads, structural dynamics and systems test. Employing FTASP concepts and approaches could greatly enhance our ability to produce final results early and diminish our reliance on preliminary and partially complete real time quick look results as the basis for major decisions in the development of airplanes and systems.

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Reference Type: Technical Manual
Author: Science Applications International Corporation, Systems Control Technology Group
Year: 1995
Title: Electro-load technical manual
Place Published: California, MD
Publisher: Science Applications International Corporation, Systems Control Technology Group
Date: April
Number of Pages: 50
Keywords: electro-load, technical manual, control algorithm, FAA requirements, time response
Abstract: Simulation and Control Technologies is the recognized leader in the development of high fidelity aerodynamic and flight control system simulations, including ELECTRO-LOAD, an Electric Control Loading (ECL) force feel system for vehicle simulations.

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Reference Type: Installation and Test Guide
Author: Science Applications International Corporation Simulation and Control Technology Group
Year: 1994
Title: Electro-load: Installation procedure and acceptance test guide
Place Published: California, MD
Publisher: Science Applications International Corporation, Simulation and Control Technology Group
Date: April
Number of Pages: 22
Keywords: electro-load, installation, test guide, physical installation, parameter calculation
Abstract: Simulation and Control Technologies is the recognized leader in the development of high fidelity aerodynamic and flight control system simulations, including ELECTRO-LOAD, an Electric Control Loading (ECL) force feel system for vehicle simulations.

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Reference Type: Magazine Article
Author: Scott, W. B.
Year: 2004
Title: Rethinking upset training
Magazine: Aviation Week & Space Technology
Volume: 160
Issue Number: 2
Pages: 39-40
Date: January 12
Number of Pages: 2
Abstract: Using simulators to develop upset-recovery procedures could lead to negative training.

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Reference Type: Conference Paper
Author: Seamster, Thomas L.; Glass, Richard H.
Year: 1990
Title: Human factors considerations in the design of displays and switches for a flight simulator's onboard Instructor/Operator Station (IOS)
Conference Name: Human Factors Society 34th Annual Meeting
Keywords: human factors, display design, instructor/operator station
Abstract: The MV-22A training device suite Operational Flight Trainer (OFT) and Aircrew System Trainer (AST) specification requirements provide for an instructor work environment that focuses on integrating the instructor's position with the training environment. This paper will describe the process to refine a display/switch design dedicated to over-the-shoulder instruction at the IOS. The time frame encompasses the period from the mockup through the IOS-specific design reviews which addresses a mature IOS

display/switch design. This new IOS display/switch design mirrors the aircraft's Multi-Function Displays (MFDs) which provide the pilots rapid and efficient access to aircraft systems and environmental data, while allowing for primary focus on flying the aircraft. Correspondingly, the IOS display/switch design for control and monitor of the training scenario, allows the instructor to focus on trainee actions, the aircraft instrument panel, and the visual system's forward field of view. Since the mockup, there has been a refinement process leading to some significant design initiatives. An analysis of this refinement process points out some key issues in designing for this new type of IOS display.

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Reference Type: Book Section
Author: Sedgwick, H. A.
Year: 1986
Title: Section IV: Space and motion perception
Editor: Boff, Kenneth R.; Kaufman, Lloyd; Thomas, James P.
Book Title: Handbook of Perception and Human Performance: Sensory Processes and Perception
City: New York
Publisher: John Wiley and Sons
Volume: I
Number of Volumes: 2
ISBN: ISBN 0-471-88544-4 (v. I)
Author's Title and Affiliation: State University of New York, College of Optometry, New York, NY

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Reference Type: Conference Paper
Author: Seidensticker, Steve; Hecker, Mary-Ellen
Year: 1985
Title: Real-time simulators: Dealing with their growing complexity
Conference Name: Interservice/Industry Training, Simulation & Education (I/ITSEC) Conference
Author's Title and Affiliation: Logicon, Inc., Tactical and Training Systems Division, San Diego, CA
Number of Pages: 5
Abstract: A number of technical and philosophical issues are emerging in the development of large real-time simulators that are going to have profound effects on the way such devices are designed and built. Simulators are becoming more complex, both in the number of functions that each must perform, and the number of disciplines involved. In the near future it will not be uncommon to use speech generation, speech understanding, artificial intelligence, image generation, complex optics, embedded processors, graphic displays, and sophisticated motion cue generators in a single simulator. Existing approaches to design, implementation, and testing cannot support the integration of these disciplines into a single harmonious system.
Fortunately, technical developments have kept pace with this problem. High speed local area networks (LAN); ever faster, smaller, and cheaper processors; cheap and plentiful memory; object oriented design techniques; and procedures oriented programming languages all have major potential application to the integration of components in large real-time systems.
This paper will explore and suggest the application of these developments to future simulators. Examples of a relatively simple operational flight trainer (OFT) and a multi-cockpit weapon system trainer (WST) designed around a set of well defined modules will be used to illustrate the concepts.

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Reference Type: Book Section
Author: Sekuler, Robert; Watamaniuk, Scott N. J.; Blake, Randolph
Year: 2002
Title: Perception of visual motion
Editor: Pashler, Hal; Yantis, Steve
Book Title: Stevens' Handbook of Experimental Psychology

City: New York
Publisher: J. Wiley
Volume: 1
Number of Volumes: 4
Series Volume: Sensation and Perception
Chapter: 4
Edition: 3rd
Author's Title and Affiliation: Sekuler: Brandeis University
Watamaniuk: Wright State University
Blake: Vanderbilt University
Notes: This is a June 2001 version as prepared for publication.
URL: http://people.brandeis.edu/~sekuler/papers/SWBchapterJune2001.pdf
Author Address: sekuler@brandeis.edu
watamaniuk@wright.edu
randolph_blake@vanderbilt.edu
Access Date: August 15, 2007

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Reference Type: Workshop/Symposia
Author: Sele, Mike; Baetge, Mike
Year of Workshop: 1983
Title: Innovative uses of aircraft for flight training
Workshop Name: Flight Training Technology for Regional/Commuter Airline Operation
Workshop Location: Moffett Field, CA
Publisher: National Aeronautics and Space Administration (NASA), Ames Research Center
Date of Workshop: September 28-30
Author's Title and Affiliation: Sele: Air Wisconsin
Baetge: NASA
Keywords: Line Oriented Flight Training (LOFT), line operations, crew member training
Abstract: (from first page) The theme of our presentation is the development of ideas and ways in which to increase effectiveness of the aircraft as a training device with particular attention to the application of LOFT concepts to the aircraft in its home environment.

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Reference Type: Report
Author: Shafer, Mary F.
Year: 1992
Title: In-flight simulation studies at the NASA Dryden Flight Research Facility
City: Washington, DC
Institution: National Aeronautics and Space Administration
Pages: 1-17
Date: July
Report Number: NASA TM-4396
Author's Title and Affiliation: NASA Dryden Flight Research Facility, P.O. Box 273, Edwards, CA 93523-0273
Number of Pages: 17
Keywords: in-flight simulation, flight test, Dryden history
Abstract: Since the late 1950's the National Aeronautics and Space Administration's Dryden Flight Research Facility has found in-flight simulation to be an invaluable tool. In-flight simulation has been used to address a wide variety of flying qualities questions, including low-lift-to-drag ratio approach characteristics for vehicles like the X-15, the lifting bodies, and the Space Shuttle; the effects of time delays in controllability of aircraft with digital flight-control systems, the causes and cures of pilot-induced oscillation in a variety of aircraft, and flight-control systems for such diverse aircraft as the X-15 and the X-

29. In-flight simulation has also been used to anticipate problems and to avoid them and to solve problems once they appear.
This paper presents an account of the in-flight simulation at the Dryden Flight Research Facility and some discussion. An extensive bibliography is included.
URL: www.nasa.gov/centers/dryden/pdf/88271main_H-1833.pdf

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Reference Type: Conference Paper
Author: Shah, Gautam H.; Cunningham, Kevin; Foster, John V.; Fremaux, C. Michael; Stewart, Eric C.; Wilborn, James E.; Gato, William; Pratt, Derek W.
Year: 2002
Title: Wind-tunnel investigation of commercial transport aircraft dynamics at extreme flight conditions
Conference Name: World Aviation Congress & Display
Conference Location: Phoenix, AZ
Publisher: SAE International
Date: November 5-7
Electronic Resource Number: 2002-01-2912
Author's Title and Affiliation: Gautam H. Shah, Kevin Cunningham, John V. Foster, C. Michael Fremaux, Eric C. Stewart: NASA Langley Research Center
James E. Wilborn, William Gato, Derek W. Pratt: The Boeing Company
Keywords: upset recovery training (URT), disorientation
Abstract: A series of low-speed static and dynamic wind tunnel tests of a commercial transport configuration over an extended angle of attack/sideslip envelope was conducted at NASA Langley Research Center. The test results are intended for use in the development of an aerodynamic simulation database for determining aircraft flight characteristics at extreme and loss-of-control conditions. This database will be used for the development of loss-of-control prevention or mitigation systems, pilot training for recovery from such conditions, and accident investigations. An overview of the wind-tunnel tests is presented and the results of the tests are evaluated with respect to traditional simulation database development techniques for modeling extreme conditions to identify regions where simulation fidelity should be addressed.

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Reference Type: Journal Article
Author: Shallo-Hoffmann, Josephine; Bronstein, Adolfo M.
Year: 2003
Title: Visual motion detection in patients with absent vestibular function
Journal: Vision Research
Volume: 43
Pages: 1589-1594
Electronic Resource Number: 10.1016/S0042-6989(03)00218-9
Number of Pages: 6
Keywords: visual motion perception, bilateral vestibular failure, oscillopsia, velocity detection
Abstract: Labyrinthine defective subjects (LDS) experience oscillopsia during head movements due to the absence of the vestibulo-ocular reflex (VOR). The purpose of this study was to compare horizontal and vertical visual motion detection in LDS during (i) body-stationary and (ii) horizontal whole-body oscillation conditions. Twelve LDS and controls detected the onset of drift direction of a grating that moved with accelerating velocity. Thresholds were raised in the patient group in both conditions. The loss of the VOR per se cannot explain raised thresholds in the body-stationary condition nor during whole-body (horizontal) oscillation with vertical grating motion. Findings indicate changes in visual processing that make LDS less sensitive to visual motion. It is postulated that these changes are due to adaptive mechanisms involved to reduce oscillopsia.

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Reference Type: Report
Author: Sharkey, Thomas J.; Ciavarelli, Anthony P.; Asbury, Charles N.
Year: 2005
Title: Skill training using adaptive technology: A better way to hover
City: Monterey, CA
Institution: Monterey Technologies, Inc.
Pages: 1-101
Date: September 2005
Type: Final
Report Number: MTI 20.202906
Number of Pages: 101
Abstract: This report describes the work performed by Monterey Technologies, Inc. under a Phase 1 Small Business Innovation Research (SBIR) contract. The goal of the work was to determine the feasibility of developing and implementing an automated, adaptive hover training controller based on human performance models and novel feedback techniques for Student Pilots (SP) in Initial Entry Rotary Wing (IERW) training. A review of the relevant literature was performed. Based on this review, an approach where a training prescription is made for each student state and skill level is recommended. This review has implications for the state of adaptive prescriptions for training psychomotor tasks relative to training of cognitive skills. The recommended training system includes descriptions and functions for several elements of the training system and the recommended software models. These models are to be developed using commercially available software designed to support a particular type of AI approach most suitable for this application. Software packages are reviewed and a suite of products appropriate for use in this application is recommended.

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Reference Type: Conference Proceedings
Author: Sharkey, Thomas J.; McCauley, Michael E.
Year of Conference: 1992
Title: Does a motion base prevent simulator sickness?
Conference Name: AIAA/AHS Flight Simulation Technologies Conference
Conference Location: Hilton Head Island, SC
Publisher: American Institute of Aeronautics and Astronautics (AIAA)
Pages: 21-28
Date: August 24-26
Electronic Resource Number: AIAA-92-4133-CP
Author's Title and Affiliation: Monterey Technologies, Inc., Carmel, CA
Number of Pages: 8
Keywords: simulator sickness, high fidelity motion cues, motion base, vertical motion simulator, motion washout, visual system
Abstract: Simulator sickness is an unwanted side effect of many current flight simulators. Various strategies for minimizing the problem have been discussed by the NASA Steering Committee on Simulator Induced Sickness. One common proposal is to provide high fidelity motion cues to reduce the discrepancy or conflict between the visually-implied motion and the actual motion. The assumption is that the reduction of cue conflict will reduce the incidence and severity of simulator sickness. This hypothesis was tested using the NASA Vertical Motion Simulator (VMS) at Moffett Field. Ten pilots flew a UH-60 Blackhawk model with two low altitude flight maneuvers: S-turns and sawtooths. These flight tasks were selected because they had generated a very high incident of simulator sickness in a previous study using a fixed-base wide FOV-simulator. The pilots flew maneuvers up to 60 minutes on each of two separate days, once with the motion base turned on and once with the motion base turned off. Several types of data were collected including periodic self-report, pre-post symptom checklists, dark focus, and pre-post postural equilibrium tests. The results indicate that the motion base condition did not result in a lower incidence or severity of simulator induced sickness.

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Reference Type: Journal Article
Author: Sharpe, D.
Year: 2004
Title: Beyond significance testing: Reforming data analysis methods in behavioral research
Journal: Canadian Psychology
Volume: 45
Issue: 4
Pages: 317-319
Date: November
Type of Article: Book review
Author's Title and Affiliation: University of Regina, Regina, SK, Canada
Number of Pages: 3
Keywords: significance testing; effect size; confidence interval estimation; statistical decision making; null hypothesis; data analysis; behavioral research
Abstract: Reviews Kline's book which reviews the controversy regarding significance testing, offers methods for effect size and confidence interval estimation, and suggests some alternative methodologies.

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Reference Type: Book Section
Author: Sheridan, Thomas; Ferrell, William R.
Year: 1974
Title: Fundamental considerations in modeling the human operator in a control system
Book Title: Man-machine systems: Information, Control and Decision Models of Human Performance
City: Cambridge, MA
Publisher: The MIT Press
Pages: 177-246
Number of Pages: 70

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Reference Type: Report
Author: Sheridan, Thomas B.
Year: 2001
Title: Considerations in development and use of a locomotive cab simulator for human factors research
Institution: Volpe National Transportation Systems Center
Date: December
Type: Research Report
Number of Pages: 11
Abstract: Consideration is being given by the Federal Rail Administration (FRA) to use of the Amtrak Acela simulator and also to the development of a new simulator facility devoted primarily for human factors research. In April 2001, Foster-Miller (Reinach 2001) issued a report examining the applicability of the Acela high speed rail simulator for human-centered research purposes. The primary intended use of that simulator is to familiarize locomotive engineers with Acela train sets; human factors research was not a consideration in specifying its design. Section 7 of the Foster-Miller report makes recommendations for the design of a simulator facility devoted to human factors research.

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Reference Type: Patent
Inventor: Sheridan, Thomas B.
Year: 2007
Title: Vehicle operations simulator with augmented reality
Issuing Organization: United States Patent Office
Country: United States of America
Assignee: David R. Sheridan

Application Number: 11/454,601
Pages: 16
International Patent Classification: G06G 7/48 (20060101)
Date: 06/16/2006
Short Title: Vehicle operations simulator with augmented reality
Patent Number: 7,246,050
Issue Date: 07/17/2007
Abstract: This invention provides in a safe and effective manner the experience of observing potential collision obstacles or other hazard images to the human operator of an otherwise conventional vehicle, (such as an automobile or aircraft) moving in a normal manner in a natural environment (such as an outdoor test track). The invention incorporates in addition to the mobile vehicle, computer-based image generation devices, and position, velocity, acceleration, measurement instruments to enable the simulated visual hazard images, including operator perception of and response to those hazard images. Making the actual moving vehicle part of the simulated hazard encounter means the vestibular (motion) cues and visual cues of the natural environment are very realistic, while only the computer-generated hazard images imposed on the natural environment view are virtual. The system results in a safe and cost efficient way of producing a realistic experience of vehicle operation encounters, including both the observation and response.
Access Date: 06/01/2010

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Reference Type: Conference Paper
Author: Sheridan, T.B.; Bürki-Cohen, J.; Corker, K.
Year: 2006
Title: Human transient into-the-loop simulation for NGATS
Conference Name: AIAA Modeling and Simulation Technologies Conference
Conference Location: Keystone, CO
Publisher: American Institute of Aeronautics and Astronautics
Date: August 21-24
Electronic Resource Number: AIAA-2006-6114
Abstract: Serious planning is underway for the United States Next Generation Air Transportation System. While design decisions are far from complete, there is consideration of having aircraft-trajectory control in space and time be determined by some combination of pilots, air-traffic personnel, and computers. Insofar as any control input is continuous in time, because of human perception and decision response times and/or computer multitasking or optimization-cycle times, there are likely to be time delays (e.g., human transients getting “into the control loop”) that could threaten control stability. Using the MATLAB® Simulink® dynamic simulation tool this paper examines some hypothetical situations and offers examples of how delays and signal sampling in aircraft control could cause unacceptable oscillations and instability.
URL: http://www.volpe.dot.gov/hf/docs/ngats-aiaa06.pdf

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Reference Type: Magazine Article
Author: Shifrin, Carole A.
Year: 1996
Title: Regional airlines special report: Changing rules challenge U.S. regionals
Magazine: Aviation Week & Space Technology
Pages: 54-55
Date: May 20
Number of Pages: 2
Keywords: RAA, Regional Airlines Association, Part 135, Part 121

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Reference Type: Conference Paper
Author: Shinn-Cunningham, B.
Year: 1998
Title: Applications of virtual auditory displays
Conference Name: 20th International Conference of the IEEE Engineering in Biology and Medical Society
Author's Title and Affiliation: Hear. Res. Center, Depts. of Cognitive and Neural Systems and Biomedical Engineering, Boston University, 677 Beacon St., Boston, MA 02215
Number of Pages: 4
Keywords: virtual environments, spatial hearing
Abstract: Current technology makes it possible to simulate naturally-occurring spatial auditory cues quite accurately. However, the cost of such a system is not justifiable, or even desirable, for all applications. This paper surveys some of the applications currently using virtual auditory displays and some of the issues important in the design of virtual auditory displays.
URL: http://cns-web.bu.edu/~shinn/pages/pdf/IEEE_VAS_Appl.pdf

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Reference Type: Report
Author: Shirachi, Douglas K.; Shirley, Richard S.
Year: 1981
Title: Visual/motion cue mismatch in a coordinated roll maneuver
City: Moffett Field, CA
Institution: National Aeronautics and Space Administration (NASA)
Date: May
Report Number: NASA-CR-166259
Number of Pages: 48
Abstract: An experiment was performed to investigate the effects of bandwidth differences between visual and motion cueing systems on pilot performance for a coordinated roll task. In addition, for visual and motion cue configurations which were judged to be acceptable, the effects of reduced motion cue scaling on pilot performance were studied to determine the scale reduction threshold for which pilot performance was significantly different from full scale pilot performance.
The major conclusions were that (1) the presence or absence of high frequency (w > 3.5 rad/sec) error information in the visual and/ or motion display systems significantly affects pilot performance, and (2) the attenuation of motion scaling while maintaining other display dynamic characteristics constant affects pilot performance.

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Reference Type: Report
Author: Shirley, Richard S.
Year: 1968
Title: Motion cues in man-vehicle control
City: Cambridge, MA
Institution: Massachusetts Institute of Technology (MIT)
Date: January
Type: Sc. D. Thesis
Report Number: MIT Report No. MVT-68-1
Abstract: An investigation is made to determine how the human operator makes use of roll motion cues in a man-vehicle control system. To this purpose the human operator's describing function is measured over a wide range of vehicle dynamics and under conditions of visual inputs only, motion inputs only, and combined visual and motion inputs. Both the describing function (amplitude and phase of the human operator's output relative to his input) and the remnant (power spectral density of that part of the human operator's output which is uncorrelated with his input) are measured as a function of frequency. The relative integral squared error is also measured. Visual inputs are made by means of a dot moving laterally on an oscilloscope, and roll motion inputs are made by means of a motion simulator.

An analytical method of correcting the experimental measurements for errors introduced by the remnant is developed and applied to the data. The corrections are generally small.
Examination of the describing function data leads to some conclusions about he human operator's use of angular motion cues in a man-vehicle control system. When the roll motion cues are added to the visual cues, the human operator is able to increase his lead in the frequency range above three radians per second. This permits him to increase his gain and cross-over frequency without decreasing his phase margin. The net effect of these changes in the human operator's control behavior is to increase the open loop gain without a loss of stability, and thus to reduce the relative integral squared error for the closed loop system.
The percentage reduction of the relative integral squared error upon the addition of the motion cues to the visual cues varies as a function of the controlled vehicle dynamics. The human operator can make the most use of motion cues for vehicle dynamics which lead to significant roll motions above one radian per second. Such vehicle dynamics include low order dynamics (1/s as opposed to $1/s^2$) and dynamics with an associated high control stick gain.
It is possible, in some cases, to use the body of data obtained for this thesis to predict actual in-flight or moving-base measurements of the human operator's describing function from fixed-base measurements of the human operator's describing function.

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Reference Type: Magazine Article
Author: Shirts, R. Garry
Year: 1992
Title: Ten secrets of successful simulations
Magazine: Training
Date: October
Author's Title and Affiliation: Simulation Training Systems
Abstract: This article by Garry Shirts originally appeared in the October 1992 issue of Training magazine. It presents 10 suggestions for developing effective simulations. It is based on Garry Shirts' experience in designing more than 40 simulations and experiential programs.
URL: http://www.stsintl.com/business/articles/tensecrets.pdf

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Reference Type: Report
Author: Showalter, Thomas W.; Miller, Robert J.
Year: 1978
Title: G-seat system step input and sinusoidal response characteristics
City: Moffett Field, CA
Institution: National Aeronautics and Space Administration (NASA), Ames Research Center
Date: June
Type: Technical Memorandum
Report Number: NASA TM - 78478
Recipient's Title and Affiliation: National Aeronautics and Space Administration, Washington, DC 20546
NASA Ames Research Center, Moffett Field, CA 94035
Keywords: G seat, step input response, frequency response
Abstract: The step input and sinusoidal response characteristics of a pneumatically driven computer controlled G seat were examined in this study. The response data show that this system can be modeled as a first order system with an 0.08 sec time lag and a 0.53 sec time constant.

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Reference Type: Report
Author: Showalter, T. W.; Parris, B. L.
Year: 1980
Title: The effects of motion and g-seat cues on pilot simulator performance of three piloting tasks
Institution: National Aeronautics and Space Administration (NASA)
Date: January
Report Number: NASA TP 1601
Author's Title and Affiliation: NASA Ames Research Center, Moffett Field, CA
Number of Pages: 38
Keywords: motion and g-seat cue evaluation, ground-based simulation, flight simulation, pilot performance in simulators
Abstract: Data are presented that show the effects of motion system cues, g-seat cues, and pilot experience on pilot performance during takeoffs with engine failures, during in-flight precision turns, and during landings with wind shear. Eight groups of USAF pilots flew a simulated KC-135 using four different cueing systems. The basic cueing system was a fixed-base type (no-motion cueing) with visual cueing. The other three systems were produced by the presence of either a motion system or a g-seat, or both. Extensive statistical analysis of the data was performed and representative performance means were examined. These data show that the addition of motion system cueing results in significant improvement in pilot performance for all three tasks: however, the use of g-seat cueing, either alone or in conjunction with the motion system, provided little if any performance improvement for these tasks and for this aircraft type.

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Reference Type: Journal Article
Author: Shulman, Adam B.
Year: 2006
Title: Financial stability and airline safety: Relationships, causes, and consequences
Journal: International Journal of Applied Aviation Studies
Volume: 6
Issue: 2
Pages: 249-270
Number of Pages: 23
Abstract: This report explores the link between an airline's profitability and its safety record. Prior literature on the subject was reviewed and discussed to provide background on the subject and form a basis for the research. While there is an abundance of literature on this topic, conclusive evidence is still disputed among experts. The purpose of this study was to determine the relationship between profitability and safety using a new and distinct methodology from former studies. By thoroughly reviewing raw data from 1995 to 2004 for the top ten U.S.-based airlines, the author has conducted an independent analysis of the information and provided quantitative evidence that justifies the conclusions presented. A statistical analysis is included to validate the results. In addition, possible causation is discussed in detail, specifically investigating the extent that investments in safety projects and the level of maintenance outsourcing impact safety.

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Reference Type: Workshop/Symposia
Author: Sifford, J. C.
Year of Workshop: 1983
Title: Management training for cockpit crews at Piedmont Flight
Workshop Name: Flight Training Technology for Regional/Commuter Airline Operation
Workshop Location: Moffett Field, CA
Publisher: National Aeronautics and Space Administration (NASA), Ames Research Center
Date of Workshop: September 28-30
Author's Title and Affiliation: Piedmont Airlines

Reference Type: Magazine Article
Author: Silbergeld, David
Year: 2000
Title: Want to polish your flight skills? Try FLY! 2K
Magazine: National Defense Magazine
Date: November
Type of Article: Online Article
Number of Pages: 2
Abstract: The original "FLY!" emerged in the 1999 flight sims, a product from developer Terminal Reality that went head-to-head with Microsoft's Flight Simulator.
URL: http://www.nationaldefensemagazine.org/archive/2000/November/Pages/Want_to4318.aspx

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Reference Type: Journal Article
Author: Silva, Rodrigo L. S.; Ramos, Alexandre C. B.
Year: 2004
Title: Avaliação de aprendizado do sistema de treinamento de pilotos
Date: 2004
Number of Pages: 9
Keywords: training evaluation, pilot training, artificial intelligence and multimedia systems
Abstract: This paper describes a concept to promote pilot skills and performance evaluation via Pilot Training System - PTS. The first objective is to provide means to aid computer based pilot training. A case study has been developed, using the ERJ145 groundschool training system, covering from common procedures to operational instabilities and emergencies maneuvers. The full system presents the opertations manual and some process instability simulations developed using multimedia and rule-based production systems, allowing the pilot to work interactively with the tutoring system in a simulation of real world situation.
Language: Portuguese

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Reference Type: Technical Report
Author: Sinacori, J. B.
Year: 1977
Title: The determination of some requirements for a helicopter flight research simulation facility
City: Moffett Field, CA
Institution: National Aeronautics and Space Administration (NASA), Ames Research Center
Date: September
Report Number: 1097-1
Author's Title and Affiliation: National Aeronautics and Space Administration, Ames Research Center

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Reference Type: Technical Report
Author: Sinacori, John B.
Year: 1986
Title: Modeling flight simulator visual/motion cue effects on pilot performance: A summary
Date: July
Report Number: AFAMRL-TR-86-064
Number of Pages: 11
Keywords: modeling flight simulator, pilot, motion cue
Abstract: The advent of the modern computer during WWII and its proliferation following that conflict has greatly enhanced the human thinking process. The words "model" and "simulation" are commonplace today and are used to describe mathematical formalisms usually implemented on a computer that mimes some intuitive thought. These models may be thought as a preliminary theory of the process involved, because if developed properly, their results are subject to experimental verification.

Reference Type: Conference Paper
Author: Sinclair, S. R. M.; West, T. C.
Year: 1978
Title: Handling qualities of a simulated STOL aircraft in natural and computer-generated turbulence and shear
Conference Name: Flight Mechanics Panel Specialists' Meeting on Piloted Aircraft Environment Simulation Techniques
Conference Location: Brussels, Belgium
Publisher: Advisory Group for Aerospace Research and Development (AGARD)
Date: April 24-27
Author's Title and Affiliation: Sinclair: Flight Research Laboratory, National Aeronautical Establishment, Ottawa, Canada K1A OR6
West: Systems Research and Development Service, U.S. Federal Aviation Administration, Washington, DC 20591
Number of Pages: 16
Keywords: STOL aircraft, turbulence, shear

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Reference Type: Journal Article
Author: Sivan, Raphael; Ish-Shalom, Jehuda; Huang, Jen-Kuang
Year: 1982
Title: An optimal control approach to the design of moving flight simulators
Journal: IEEE Transactions on Systems, Man, and Cybernetics
Volume: SMC-12
Issue: 6
Pages: 818-827
Number of Pages: 10
Keywords: optimal control approach, moving flight simulators, ground based motion simulators, washout filter, cross-product scheme, crossfeed scheme, parameter optimization, optimal model reference designs, vestibular system, washout matrix
Abstract: An abstract simulator design problem is formulated as follows: we are given a dynamic system S^a called the actual system and another dynamic system S^s called a simulator for S^a. Furthermore, we are given an input signal which drives the actual system S^a. The problem is to find an operator, properly constrained, which generates the input to the simulator S^s on the basis of the input to S^a so that the discrepancy between the output S^a and S^s is as small as possible. This abstract simulator design problem is brought in the form of an optimal control problem and then solved for the linear-quadratic Gaussian special case. Next the solution of the abstract simulator problem is applied to the design of the motion generators for motion simulators. A fairly elaborate mathematical model of the vestibular organs is used. The optimization criterion that is selected is the mean-square difference between the physiological outputs of vestibular organs for the pilot in the airplane and for the pilot in the simulator. The dynamical equations are linearized and the input signal is modeled as a random process with a rational power spectral density. Subject to the above assumptions, the optimal structure as the motion generator for the simulator, also called a washout filter is derived. This method stands in contrast to existing design schemes for motion generators which generally assume a certain fixed structure for the motion generator and concentrate on optimizing its parameters. This paper concludes with an example of a design for a two degree of freedom flight simulator including simulations for simple inputs.

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Reference Type: Conference Proceedings
Author: Smaili, Hafid; Jansen, Hans; Naseri, Amir; Groen, Eric L.; Stroosma, Olaf
Year of Conference: 2007
Title: Pilot motion perception and control during a simulated decrab maneuver
Conference Name: AIAA Modeling and Simulation Technologies Conference and Exhibit
Conference Location: Hilton Head, SC

Publisher: American Institute of Aeronautics and Astronautics (AIAA)
Date: August 20-23
Electronic Resource Number: AIAA 2007-6797
Author's Title and Affiliation: Smaili: R&D Engineer, Cockpit and Flight Operations Department, National Aerospace Laboratory NLR, P.O. Box 90502, 1059 CM Amsterdam, The Netherlands
Jansen: Senior Research Engineer, Training and Simulation Department, National Aerospace Laboratory NLR, P.O. Box 90502, 1059 CM Amsterdam, The Netherlands
Naseri: PhD Candidate, Institute for Aerospace Studies, University of Toronto, 4925 Dufferin St.,Toronto, ON, M3H 5T6 Canada
Groen: Aerospace Physiologist, Education and Training Department, TNO Human Factors, P.O. Box 23, 3769 ZG, Soesterberg, The Netherlands
Stroosma: Research Engineer, Delft Control and Simulation Division, Delft University of Technology, P.O. Box 5058, 2600 GB, Delft, The Netherlands
Abstract: A set of experiments were conducted on the National Aerospace Laboratory (NLR) GRACE research flight simulation facility to determine the effects of sway, yaw and roll motion on perceived motion fidelity, motion perception, pilot workload and pilot compensation. Fourteen pilots were asked to perform a manual decrab maneuver when the aircraft was on final approach with a 30 knots crosswind. Platform yaw, sway and roll motions were varied independently to examine their relative contribution to the pilot's judgments on perceived motion cues and workload. To determine possible effects of workload in the pilot's opinion about motion fidelity and perception of motion, pilots were grouped in pairs. For each simulator run, one pilot was asked to fly the aircraft while the other pilot was asked to monitor the maneuver. Both pilots answered the same questionnaire after each run. The results show that perception of simulator motion was positively affected by platform sway for both pilots-flying and pilots-not-flying. Platform roll had only a main effect on the perceived motion of the pilots-not-flying. Platform yaw motion seemed to have a positive effect on motion perception only in the absence of platform sway. The pilot motion fidelity ratings show that platform sway improved the fidelity ratings for the pilots-not-flying only. Platform roll (in the absence of sway) also showed to have a positive effect on pilot fidelity ratings. On average, pilot fidelity ratings were higher when the pilot was controlling the aircraft. Handling qualities results show that pilots felt less compensation was required when platform sway was present. This was confirmed by the decrease in pilot pedal and column activity when platform sway was present. The results of the experiment as described in this paper will support our previous studies in the development of objective evaluation criteria for the optimization of simulator motion cues.

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Reference Type: Report
Author: Smith, R. Marshall; Chung, Victoria I.; Martinez, Debbie
Year: 1994
Title: Transport delays associated with the NASA Langley flight simulation facility
Number of Pages: 12

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Reference Type: Conference Proceedings
Author: Smith, T. A.; Nielsen, Z. A.; Reichenbach, E. Y.; Urnes, J. M.
Year of Conference: 2009
Title: Dynamic structural fault detection and identification
Conference Name: AIAA Guidance, Navigation, and Control Conference
Conference Location: Chicago, IL
Publisher: AIAA
Pages: 1-8
Date: Aug. 10-13
Electronic Resource Number: AIAA 2009-6262
Author's Title and Affiliation: Smith: Engineer – Guidance, Navigation and Controls, Boeing Research & Technology, The Boeing Company, St. Louis, Missouri

Nielsen: Engineer – Guidance, Navigation and Controls, Boeing Research & Technology, The Boeing Company, St. Louis, Missouri
Reichenbach: Technical Fellow - Aeroservoelasticity, Boeing Research & Technology, The Boeing Company, St. Louis, Missouri
Urnes: Engineering Manager, Boeing Research & Technology
Number of Pages: 8
Keywords: Dynamic Flight Envelope Assessment and Prediction (DFEAP) program, flight envelope
Abstract: The Dynamic Flight Envelope Assessment and Prediction (DFEAP) program is a NASA funded research effort being conducted as part of NASA's Aviation Safety Program. The goal of the DFEAP program is to provide a computational framework which will provide accurate assessment of a safe maneuvering envelope for a structurally impaired aircraft and a means to ensure the aircraft remains within this envelope. The proposed system will use the flight control system to ensure that structural limits are not exceeded. These limits are determined online by the DFEAP system. The DFEAP program will be described and work to date will be discussed.

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Reference Type: Journal Article
Author: Smode, A. F.
Year: 1974
Title: Recent developments in instructor station design and utilization for flight simulators
Journal: Human Factors
Volume: 16
Issue: 1
Pages: 1-18
Author's Title and Affiliation: Dunlap and Associates, Inc., Darien, CT
Number of Pages: 19
Abstract: The instructional capability of the training simulator has improved in tempo with simulation technology. The business of shaping student behaviors has achieved a leap forward in efficiency due to digital computation and the computer display terminal. This paper discusses the impact of computer assistance on the capability for structuring and controlling synthetic flight training, and examines the instructional potential of the "new breed" of flight simulators presently on-line or in the developmental stage. A number of recent innovations in instructor station design is described. These developing, student-centered instructional techniques for promoting training effectiveness place the simulator quite realistically in contention as a major flight training medium of the future.

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Reference Type: Conference Paper
Author: Snow, Allen E.; Moon, Richard N.
Year: 1986
Title: Providing high performance visual simulation at low cost, revisited
Conference Name: Interservice/Industry Training, Simulation & Education (I/ITSEC) Conference
Author's Title and Affiliation: Evans & Sutherland Computer Corporation, Salt lake City, UT
Number of Pages: 6
Abstract: In the process of transitioning from the theoretical to the actual, things often change greatly. This is also the case in the move from system design, to system implementation and finally the actual performance characterization. In a follow-up to last year's paper "Providing High Performance Visual Simulation at Low Cost," which described the system design and architecture, this paper will discuss what has been learned in the actual implementation and use of this system.
An evaluation of the low cost approach is presented, delineating the system capabilities and limitations under various training requirements. One aspect that will be discussed at length is the channelized system architecture and how this architecture responds to different types of visual imaging simulation including sensor channels, narrow fields of view, and combinations of imaging channels, all used in the same system.

Reference Type: Electronic Article
Author: Snowden, Robert J.; Freeman, Tom C. A.
Year: 2004
Title: The visual perception of motion
Periodical Title: Current Biology
Volume: 14
Issue: 9
URL: http://www.sciencedirect.com/science?_ob=ArticleURL&_udi=B6VRT-4DG5TDG-6&_user=645219&_rdoc=1&_fmt=&_orig=search&_sort=d&_docanchor=&view=c&_acct=C000034688&_version=1&_urlVersion=0&_userid=645219&md5=c0ab5d89db3c99264c64fe4c451cc07f
Access Date: August 14, 2007

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Reference Type: Journal Article
Author: So, Richard H. Y.; Ho, Andy; Lo, W.T.
Year: 2001
Title: A metric to quantify virtual scene movement for the study of cybersickness: Definition, implementation, and verification
Journal: Presence
Volume: 10
Issue: 2
Pages: 193-215
Date: April
Author's Title and Affiliation: Human Performance and Virtual Reality Laboratory
Hong Kong University of Science and Technology
Number of Pages: 23
Abstract: This paper presents a metric to quantify visual scene movement perceived inside a virtual environment (VE) and illustrates how this method could be used in future studies to determine a cybersickness dose value to predict levels of cybersickness in VEs. Sensory conflict theories predict that cybersickness produced by a VE is a kind of visually induced motion sickness. A comprehensive review indicates that there is only one subjective measure to quantify visual stimuli presented inside a VE. A metric, referred to as *spatial velocity* (SV), is proposed. It combines objective measures of scene complexity and scene movement velocity. The theoretical basis for the proposed SV metric and the algorithms for its implementation are presented. Data from two previous experiments on cybersickness were reanalyzed using the metric. Results showed that increasing SV by either increasing the scene complexity or scene velocity significantly increased the rated level of cybersickness. A strong correlation between SV and the level of cybersickness was found. The use of the spatial velocity metric to predict levels of cybersickness is also discussed.

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Reference Type: Conference Proceedings
Author: Soyka, F.; Teufel, H. J.; Beykirch, K. A.; Giordano, Robuffo P.; Butler, J. S.; Nieuwenhuizen, F. M.; Bülthoff, H. H.
Year of Conference: 2009
Title: Does jerk have to be considered in linear motion simulation?
Conference Name: AIAA Modeling and Simulation Technologies Conference
Conference Location: Chicago, IL
Publisher: American Institute of Aeronautics and Astronautics (AIAA)
Pages: 1-8
Date: Aug. 10-13
Electronic Resource Number: AIAA-2009-6245
Author's Title and Affiliation: Soyka & Nieuwenhuizen: PhD Candidates, Max Planck Institute for Biological Cybernetics, Tübingen, Germany

Teufel, Beykirch, Giordano, & Butler: Research Scientists, Max Planck Institute for Biological Cybernetics, Tübingen, Germany
Bülthoff: Professor and Director, Max Planck Institute for Biological Cybernetics, Tübingen, Germany
Number of Pages: 8
Keywords: motion perception threshold, jerk, linear motion
Abstract: Perceptual thresholds for the detection of the direction of linear motion are important for motion simulation. There are situations in which a subject should not perceive the motion direction as, e.g., during repositioning of a simulator, but also opposite cases where a certain motion percept must intentionally be induced in the subject. The exact dependency of the perceptual thresholds on the time evolution of the presented motion profile is still an open question. Previous studies have found evidence for a sensitivity of the thresholds on the rate of change of acceleration, called jerk. In this study we investigate three motion profiles which differ in their jerk characteristics. We want to evaluate which profile can move people furthest in the horizontal plane in a given time without them noticing the direction. Our results suggest that a profile with a minimum peak jerk value should be chosen.

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Reference Type: Edited Book
Editor: Spanitz, Jackie
Year: 1995
Title: Federal Aviation Regulations Parts 25, 63, and 121
City: Renton
Publisher: Aviation Supplies and Academics, Inc. (ASA)

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Reference Type: Magazine Article
Author: Sparaco, Pierre
Year: 1994
Title: Human factors cited in French A320 crash
Magazine: Aviation Week & Space Technology
Pages: 30-31
Date: January 3
Number of Pages: 2

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Reference Type: Conference Paper
Author: Spenny, Curtis H; Liebst, Bradley S.
Year: 2002
Title: Assessment of motion devices used for spatial orientation research and training
Conference Name: RTO HFM Symposium on "Spatial Disorientation in Military Vehicles: Causes, Consequences, and Cures"
Conference Location: La Coruña, Spain
Date: Apr 2002
Number of Pages: 19
Abstract: There are many unresolved issues related to motion-based simulators including: 1) should they even be used, 2) if so, what drive configurations might be preferred and to what aspects of flight should they be applied, 3) what motion cues and artifacts are critical, 4) what drive algorithm or set of drive algorithms best utilizes the motion capabilities of a given configuration to emulate critical aircraft motion cues while producing minimal artifacts, and 5) how can pilot-driven algorithms be made more effective at teaching recovery from the perceptual conflicts of spatial disorientation? None of these questions are answered by this paper. What the paper does contain is a description of the capability of a computer simulation of motion simulators that can be used to help quantitatively address these questions. A sample aircraft maneuver is evaluated for several variants of drive configuration and drive algorithm to illustrate the measures for quantitative comparison of motion systems and the level of effort and input data

required to make the comparison. The paper indicates the status of an ongoing effort to develop a modeling tool for use by the spatial orientation and flight simulation communities to gain further understanding of the role of motion simulators.

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Reference Type: Journal Article
Author: Stanney, Kay M.; Hash, Phillip
Year: 1998
Title: Locus of user-initiated control in virtual environments: Influences on cybersickness
Journal: Presence: Teleoperators & Virtual Environments
Volume: 7
Issue: 5
Pages: 447-460
Date: October
Author's Title and Affiliation: University of Central Florida, Department of Industrial Engineering and Management Systems, Orlando, FL 32816-2450 USA
Keywords: cybersickness, simulator sickness, user-initiated control, virtual environments
Abstract: Cybersickness is a pervasive and deleterious effect of human-virtual environment interaction. This paper applies motion-sickness adaptation theory to cyber sickness in virtual environments to determine if the degree of user-initiated control can suppress sickness. It is suggested that if users are allowed some level of control over their movement within a virtual environment, cybersickness will not be as severe as that resulting from an environment in which users must follow a predetermined (i.e., scripted) path of movement. While past motion-sickness studies have examined control versus no control, the present study focuses on modifying the level of user-initiated control such that it matches the needs of the task characteristics while minimizing sickness. The degree of user sickness was tested under passive, active, and active-passive control scenarios. As measured by the Simulator Sickness Questionnaire, the active (i.e., complete control) condition reduced the severity of symptoms experienced as compared to the passive (i.e., no control) condition, but did not do so as completely as the active-passive (i.e., coupled control) condition. The implication is that the level of user-initiated control can be manipulated to modify the deleterious effects of human-virtual environment interaction.
Author Address: stanney@iems.engr.ucf.edu

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Reference Type: Report
Author: Stapleford, Robert L.; Peters, Richard A.; Alex, Fred R.
Year: 1969
Title: Experiments and a model for pilot dynamics with visual and motion inputs
Institution: NASA
Pages: 115
Date: May
Type: NASA Contractor Report
Report Number: CR 1325
Author's Title and Affiliation: Systems Technology, Inc., Hawthorne, CA
Recipient's Title and Affiliation: NASA Ames Research Center
Number of Pages: 115
Keywords: pilot dynamics, pilot model, visual feedback, motion feedback
Abstract: This report describes the results of a simulator program to investigate the effects of motion cues on a manual-control tracking task. The experimental variables were controlled-element dynamics, linear motion characteristics, and angular motion characteristics. The data obtained include: pilot describing functions, both overall (combined visual and motion feedbacks) and separate (independent visual and motion pathways); remnant characteristics; and tracking performance. These data are also compared with previous experimental results.
From the previous and present data, a multimodality pilot model for both visual and motion feedbacks is derived. The dynamics of the two (angular and linear) motion feedback paths and the integration of visual

and motion feedbacks are discussed. The overall effects of motion on the crossover model are found to be the lower pilot effective time delays and higher crossover frequencies. The changes are roughly 0.15 sec and 1 rad/sec. These effects are primarily due to an angular rate feedback via the semicircular canals. The lead provided by this vestibular path allows the pilot to reduce his lead in the visual path and increase his low frequency gain. The relative magnitudes of the visual and vestibular feedbacks depend on the controlled element dynamics (whether or not pilot low frequency lead equalization is required). The implications of the experimental data and the multimodality pilot model on the design requirements for moving-base simulators are also reviewed. While the effects of motion cues on manual tracking, failure detection, and realism must be considered, the only definitive requirements are those relating to tracking. Translational motion cues appear to be generally less important than rotational ones, although linear motions can be significant in special situations. A conservative estimate for the requirements on angular cues seems to be good fidelity over the frequency range of 0.5-10 rad/sec. A procedure for establishing tracking requirements for a specific problem is outlined.
URL: http://ntrs.nasa.gov/archive/nasa/casi.ntrs.nasa.gov/19690018693_1969018693.pdf

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Reference Type: Conference Paper
Author: Staples, K. J.
Year: 1970
Title: Motion, visual, and aural cues in piloted flight simulation
Conference Name: Simulation; Flight Mechanics Panel
Conference Location: Ames Research Center, Moffett Field, CA
Publisher: Advisory Group for Aerospace Research and Development (AGARD)
Date: March
Author's Title and Affiliation: Royal Aircraft Establishment, Bedford, England
Number of Pages: 23
Keywords: cues, motion, visual, aural, yaw motion, cue conflict
Abstract: An analysis is made of the part played by various cues in simulation. The aim is to highlight the problems rather than to summarize the state of the art. Each cue is considered in turn with particular emphasis on the interaction with human physiological sensors. The deficiencies in the cues compared with flying an actual aircraft are stated, and some assessment of their relative importance is attempted. The substitution of one cue by another is mentioned and the effect of the interaction between cues is discussed.
Notes: Lead discussion by R. Deque, O. H. Gerlach, and Richard S. Bray. Open discussion also included.

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Reference Type: Conference Paper
Author: Staples, K. J.; Love, W; Parkinson, D.
Year: 1985
Title: Progress in the implementation of AGARD-AR-144 in motion system assessment and monitoring
Conference Name: Flight Mechanics Panel Symposium on Flight Simulation
Conference Location: Cambridge, United Kingdom
Publisher: Advisory Group for Aerospace Research and Development (AGARD)
Date: September 30 - October 3
Author's Title and Affiliation: Staples: Royal Aircraft Establishment, Bedford MK41 6AE
Love: Cranfield Institute of Technology, Cranfield, Bedford MK43 0AL
Parkinson: Singer Link Miles, Lancing, West Sussex BN15 8UE
Number of Pages: 11
Keywords: AGARD-AR-144, motion systems
Abstract: After a brief explanation of the techniques defined in AGARD-AR-144 a description is given of two systems which have been built and tested to satisfy the requirements in the AGARD Report. Each system is stand-alone and only requires the user to supply the sensors on the motion system itself. One system, from Singer Link Miles, is especially suited to six-degrees-of-freedom, synergistic motion

systems, whereas the other, from the Cranfield Institute of Technology, is more appropriate to systems with independent axes. The systems have each been used on several different motion systems and some sampled measured results are given.
Notes: Published in September 1986.

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Reference Type: Presentations
Author: State University of New York at Binghamton
Year: 1999
Title: Flight and ground vehicle simulation update
Date: January 11-15
Type: CD of Powerpoint Presentations
Author's Title and Affiliation: Office of Continuing Education, Watson School of Engineering, State University of New York, Binghamton, NY
Abstract: Contents:
Fundamentals of Simulation
Professor Frank M. Cardullo
State University of New York at Binghamton

Simulators as Tools for Training and Design
Professor John M. Flach
Wright State University

Mathematical Modeling
R. Thomas Galloway
Naval Air Warfare Center, Training Systems Division
Simulator Validation and Verification

Visual Simulation Overview
Walter S. Chambers
Future Technology, Inc.

Visual Display Systems
Dr. James L. Davis
GRADIENT Inc.
NON-CGI
VISUAL IMAGE GENERATION
Dr. James L. Davis
GRADIENT Inc.

Motion and Force Cueing I, Whole-body motion
Dr. Edward A. Martin
Wright-Patterson Air Force Base

Motion and Force Cueing II
Professor Frank M. Cardullo
State University of New York at Binghamton

Flight Control System Simulation
James R. Takats
OPINICUS Corporation

Distributed Simulation
Christina Bouwens
Science Application International Corporation

Flight Simulator Qualification
Paul A. Ray
FAA

Computer Image Generation
Michael Fortin
Raytheon Corporation

PC Image Generators
Roy W. Latham
Computer Graphics Systems
Development Corporation (CGSD)
Real Time Computing

Simulator Systems Integration
Professor Frank M. Cardullo
State University of New York at Binghamton

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Reference Type: Journal Article
Author: Stedmon, Alex W.; Sharples, Sarah; Littlewood, Robert; Cox, Gemma; Patel, Harshada; Wilson, John R.
Year: 2007
Title: Datalink in air traffic management: Human factors issues in communications
Journal: Applied Ergonomics
Volume: 38
Issue: 4
Pages: 473-480
Electronic Resource Number: 10.1016/j.apergo.2007.01.013
Number of Pages: 8
Keywords: datalink, air traffic management, flightdeck of the future, air traffic control, speech, text, communications
Abstract: This paper examines issues underpinning the potential move in aviation away from real speech radiotelephony (R/T) communications towards datalink communications involving text and synthetic speech communications. Using a novel air traffic control (ATC) task, two experiments are reported. Experiment 1 compared the use of speech and text while Experiment 2 compared the use of real and synthetic speech communications. Results indicated that generally there were no significant differences between speech and text communications and that either type could be used without any main effects on performance. However, a number of specific differences were observed across the different phases of the scenarios indicating that workload levels may be more varied when speech communications are used. Experiment 2 illustrated that participants placed a greater level of trust in real speech than synthetic speech, and trusted true communications more than false communications (regardless of whether they were real or synthetic voices). The findings are considered in terms of datalink initiatives for future air traffic management, the importance placed on real speech R/T communications, and the need to develop more natural synthetic speech in this application area.

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Reference Type: Magazine Article
Author: Steenblik, Jan W.
Year: 2003
Title: Free upset recovery flight training
Magazine: Air Line Pilot
Pages: 12
Date: February 12

Author's Title and Affiliation: Technical Editor, Air Line Pilot
Keywords: upset recovery training (URT)
Abstract: For decades, the leading cause of airline fatalities worldwide has been controlled flight into terrain (CFIT). In recent years, however, thanks in large measure to the joint efforts of aviation authorities, airlines, and a number of aviation safety organizations (including ALPA), plus introduction of enhanced ground proximity warning systems, CFIT, while still a serious safety concern, is no longer the leading cause of airline fatalities.
The new No. 1 killer? Loss-of-control accidents.
URL: http://www.alpa.org/portals/alpa/magazine/2003/Feb2003_FreeUpsetRecovery.htm

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Reference Type: Journal Article
Author: Stern, R. M.; Hu, S.; Anderson, R. B.; Leibowitz, H. W.; Kock, K. L
Year: 1990
Title: The effects of fixation and restricted visual field on vection-induced motion sickness
Journal: Aviation, Space, and Environmental Medicine (ASEM)
Volume: 61
Issue: 8
Pages: 712-715
Author's Title and Affiliation: Department of Psychology and Division of Gastroenterology, Department of Medicine, Penn State University, University Park and Hershey, PA
Number of Pages: 4
Abstract: Approximately 60% of healthy human subjects experience motion sickness when exposed to a rotating optokinetic drum. The purpose of the present study was to determine the effects of certain visual factors on susceptibility to motion sickness. Vection data (illusory self-motion), horizontal eye movement recordings, subjective motion sickness report, and a measure of gastric myoelectric activity (electrogastrogram, EGG) were obtained from 45 subjects, who were randomly divided into the following three groups: a control group that observed the entire visual field with no fixation, a group that fixated on a central target, and a third group that had a visual field restricted to 15 degrees. The experimental session was divided into the following three 12-min periods: baseline, drum rotation, and recovery. The results showed that fixation greatly reduced nystagmus and slightly reduced vection. The restricted visual field slightly reduced nystagmus and greatly reduced vection. Both of these manipulations significantly reduced symptoms of motion sickness and tachyarrhythmia, the abnormal gastric myoelectric activity that usually accompanies nausea.

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Reference Type: Book
Author: Stevens, Brian L.; Lewis, Frank L.
Year: 1992
Title: Aircraft control and simulation
City: New York
Publisher: John Wiley & Sons
ISBN: ISBN 0-471-61397-5
Author's Title and Affiliation: Stevens: Georgia Tech Research Institute
Lewis: The University of Texas at Arlington

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Reference Type: Journal Article
Author: Stewart, John E. II; Dohme, John A.; Nullmeyer, Robert T.
Year: 2002
Title: U.S. Army initial entry rotary-wing transfer of training research
Journal: International Journal of Aviation Psychology
Volume: 12

Issue: 4
Pages: 359-357
Author's Title and Affiliation: Stewart and Dohme: U.S. Army Research Institute
Nullmeyer: Air Force Research Laboratory
Keywords: helicopter, rotary-wing, initial entry rotary wing training (IERW), simulator training, UH-1
Abstract: Early fixed-wing research demonstrated that potential cost and training benefits could be derived from simulation-augmented flight training. More recent research in this area has been the exception, not the rule. This is especially true for rotary-wing aircrew training research. Currently, the U.S. Army does not use simulation in the primary (contact) phase of initial entry rotary-wing (IERW) training. Research performed by the Army Research Institute showed that a combination of synthetic flight simulation and criterion-based training during the primary phase of IERW had the potential for saving time and costs in the aircraft. This research was performed using a low-cost simulator based upon the UH-1 helicopter. In the 4 quasi-experiments reported, positive transfer effectiveness ratios (TERs) were observed for most flight maneuvers pretrained in the simulator; student pilots in the simulator group required fewer iterations than control participants to reach proficiency on most flight maneuvers in the UH-1 training aircraft. As the visual display and flight modeling systems were upgraded, greater TERs were observed, and differences among groups tended to become significant.
URL: http://www.leaonline.com/doi/pdf/10.1207/S15327108IJAP1204_3

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Reference Type: Report
Author: Sticha, Paul J.; Singer, Michael J.; Blackstens, Ric H.; Morrison, John E.; Cross, Kenneth D.
Year: 1990
Title: Research and methods for simulation design: State of the art
City: Alexandria, VA
Institution: United States Army Research Institute for the Behavioral and Social Sciences
Date: September
Type: Final Technical Report
Report Number: ARI Technical Report 914
Keywords: training system optimization, training system model, medium selection, fidelity, instructional features, training resource allocation
Abstract: This report reviews the empirical results and analytical methods available to the training-device designer for tradeoff analyses necessary to predict cost-efficient training device designs. It addresses the problem of training system optimization in three ways. First, it describes existing methods that can aid training-device design functions. The function and operations of methods are compared to the model for the optimization of simulation-based training systems (OSBATS) developed for this project. Second, it reviews research on several issues related to training-device optimization. The issues covered in the review include training-device fidelity, instructional featured, skill acquisition, skill retention transfer of training, and cost estimation. Third, the review organizes the requirements for future research on the topics and sets priorities for research topics based on their cost and the benefit they could offer to the training-device designer. The review focused on quantitative models that can be used to estimate training cost and effectiveness and to determine optimal levels of training-device design variables. The research plan identifies the topics that reduce critical gaps in our knowledge at a reasonable cost. Research addressing (a) relative impact of fidelity features and instructional features on training effectiveness, (b) effects of student aptitudes on training-device design, and organization of nonmonetary reasons for simulation-based training can produce a moderate benefit at a relatively low cost. The most critical research issues involve the impacts of training-device fidelity and instructional features on training effectiveness.
This review provides information that may be used by researchers who wish to develop or improve methods to aid the training-device designers. Designers may use this review to identify methods to aid the training-device design process and individuals who manage research programs may use this information to set priorities for future research efforts.
Notes: This report was produced by Human Resources Research Organization, 1100 South Washington Street, Alexandria, VA 22314.

Reference Type: Journal Article
Author: Stoffregen, Thomas A.; Hettinger, Lawrence
Year: 2000
Title: Postural instability and motion sickness in a fixed-base flight simulator
Journal: Human Factors
Volume: 42
Issue: 3
Pages: 458-469
Date: Fall
Author's Title and Affiliation: Stoffregen: University of Cincinnati
Hettinger: Logicon Technical Services Inc
Number of Pages: 12
Abstract: We evaluated the prediction that postural instability would precede the subjective symptoms of motion sickness in a fixed-base flight simulator. Participants sat in a cockpit in a video projection dome and were exposed to optical flow that oscillated in the roll axis with exposure durations typical of flight simulation. The frequencies of oscillation were those that characterize spontaneous postural sway during stance. Head motion was measured prior to and during exposure to imposed optical flow. Of 14 participants, 6 were classified as motion sick, either during or after exposure to the optical oscillation. Prior to the onset of subjective symptoms, head motion among participants who later became sick was significantly greater than among participants who did not become motion sick. We argue that the results support the postural instability theory of motion sickness. Actual or potential applications include the prevention or mitigation of motion sickness in virtual environments.

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Reference Type: Magazine Article
Author: Stowe, Steve
Year: 2000
Title: Fly-by-wire: A primer for aviation accident investigators
Magazine: Air Line Pilot
Pages: 18
Date: February
Author's Title and Affiliation: First Officer, Delta; Local Air Safety Chairman, Delta Council 16
Keywords: Fly-by-wire (FBW), upset recovery training (URT)
Abstract: Fly-by-wire (FBW) is the generally accepted term for flight control systems in which a computer processes the pilot's control movements and sends electric signals to the flight control surface actuators without any mechanical linkage. While enhancing aircraft performance and flying qualities, today's fly-by-wire systems present their own unique hazards and risks. Aviation safety officers and accident investigators need to become "fly-by-wire literate" to be effective today. Here, I briefly introduce fly-by-wire concepts, acquaint you with some of the FBW lingo, and look at safety applications.
URL: http://cf.alpa.org/internet/alp/2000/febfbw.htm

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Reference Type: Journal Article
Author: Strachan, Ian
Year: 1998
Title: To move or not to move
Journal: Aerospace International
Volume: 25
Issue: 9
Pages: 48-52
Date: September
Abstract: The importance of producing cues of real motion in flight simulators, such as acceleration onset cues and motion cues from visual sources, is discussed. It is noted that, although in the military case many aspects of the training can be satisfied only by real aircraft flight, much cost-effective training

can be undertaken in a simulator which accurately replicates the flight handling and other cues. The discussion covers relevant standards and regulations, motion platforms, simulator latency, simulator sickness, formation flying and air refueling, control law development, and training for high g. (AIAA)

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Reference Type: Magazine Article
Author: Strachan, I.
Year: 2006
Title: Radical ideas at RAeS
Magazine: Journal for Civil Aviation Training (CAT)
Issue Number: 1
Pages: 26-27
Keywords: RAeS, Flight Simulation Group (FSG), International Working Group (IWG)
Abstract: The Flight Simulation Group (FSG) of the Royal Aeronautical Society (RAeS) in UK organizes two two-day conferences each year in London, one in June and the other in November. The June meeting is normally on general matters; the November event on a more specialized subject. The specialist subject in November 2005 was, 'Regulation, is it time for an update?'
URL: http://cat.texterity.com/cat/2006-1/?pg=27

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Reference Type: Magazine Article
Author: Strachan, Ian
Year: 2008
Title: Rationalizing the regs - RAeS plays pivotal role in sim training
Magazine: Journal for Civil Aviation Training (CAT)
Issue Number: 1
Pages: 22-24
Keywords: Royal Aeronautical Society (RAeS), Flight Simulation Group (FSG), International Working Group (IWG), International Civil Aviation Organization (ICAO), Manual of Criteria for the Qualification of Flight Simulators (ICAO Doc. 9625)
Abstract: A working group has been looking at updating international technical standards for flight simulation training devices. Objectives include allowing for new developments in simulation technology, and rationalizing categories and levels that exist across different regulatory authorities.
URL: http://cat.texterity.com/cat/2008-1/

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Reference Type: Conference Paper
Author: Strachan, I. W.
Year: 1995
Title: Cueing for motion
Conference Name: RAeS Flight Simulation Group Symposium
Publisher: Royal Aeronautical Society (RAeS)
Date: May 17
Abstract: Nine types of motion cues used by a pilot in flight are analyzed and evaluated for their characteristics, their strengths and limitations.
These flight cues are then compared with those which it is possible to generate in a simulated environment. Conclusions are drawn on the efficacy of various simulation systems. These include motion platforms of different sizes, degrees of freedom and other performance aspects such as latency, accelerations, bandwidth, buffet and vibration. Cueing for high Gz is discussed, considering G seats, anti-G suits, G-dimming, and the use of centrifuge-mounted cockpits.
Motion cues from visual sources are also discussed. This includes head down and head-up instruments, sensor displays, and outside-world displays. Outside world scenes are considered from good visibility day conditions, through sensor displays, poor visibility and night, to pure instrument flight. Flight regimes

discussed include taxiing, takeoff, enroute, approach and landing (including training for appropriate emergencies); and, for the military, low flying and ground attack, air combat, formation, and air-to-air refueling.
Conclusions are then drawn as to the best mix of simulator systems, the interfaces and phasing between systems, and the training tasks best carried out by different combinations of systems. The overall conclusion is that simulator systems are available to do most training tasks except realistic cueing for high Gz.
Civil training can therefore be particularly effectively accomplished and this is borne out by the success of Zero Flight Time simulator conversions. Most aspects of military training can also be effective using simulation systems; even in high-G situations there are many simulator systems that will produce a significant amount of cueing.
The civil side is working well under a sound system of standards and regulation, but the military side has some way to go both in a commitment to available technology and in creating a structure of standards and regulation as efficient as that developed over many years for civil aircraft.

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Reference Type: Unpublished Work
Author: Strachan, Ian W.
Year: 2006
Title of Work: Motion and visual cues in the real world and in simulators: Principles and practice
Pages: 1-20, plus appendices
Date: July 1
Author's Title and Affiliation: MBE AFC FRAeS
Abstract: This paper analyzes the cues used for control of the flight path in an aircraft and other vehicles, relates them to the simulator systems available, and draws conclusions. Aircraft systems are mainly discussed because all six degrees of freedom are constantly involved and so they demonstrate the principles of motion cueing better than vehicles with less degrees of freedom. However, the same principles apply to simulations of other moving vehicles.

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Reference Type: Journal Article
Author: Strasburger, Hans
Year: 2001
Title: Converting between measures of slope of the psychometric function
Journal: Perception and Psychophysics
Author's Title and Affiliation: Ludwig-Maximilians-Universität, München, Germany and Otto-von-Guericke-Universität, Magdeburg, Germany
Number of Pages: 9
Abstract: The psychometric function's slope is a basic descriptor of human performance in a sensory task. It provides information about the reliability of psychophysical threshold estimates, and further allows to compare thresholds that were obtained at different performance criterion levels. Unfortunately, there is a bewildering variety of slope measures in use which hinders the communication between authors and the empirical validation of slope estimates by comparing slope results across studies. The present note provides conversion formulas for the most popular cases, including the logistic, Weibull, Quick, cumulative normal and hyperbolic tangent functions as analytic representations, in both linear and log coordinates and to different log bases, for the practical decilog unit, the empirically based interquartile-range (IQR) measure of slope, and slope in a d' representation of performance.
URL:
http://docserver.ingentaconnect.com/deliver/connect/psocpubs/00315117/v63n8/s6.pdf?expires=1191008844&id=39685501&titleid=1014&accname=U.S.+Dept.+of+Transportation&checksum=44F074A297E4DC83A8A46FDCFC82EA53

Reference Type: Conference Paper
Author: Strassburger, Axel
Year: 2003
Title: Simulator JOINT
Conference Name: Simulation of the Environment
Conference Location: London, UK
Publisher: Royal Aeronautical Society (RAeS)
Number of Pages: 11
Abstract: Simulator JOINT is an abbreviation for Joint Operational Incidents Training and means a common real life training of both pilots and air traffic controllers to achieve a more realistic training for both groups. Subject of this article is the experience made with that kind of training which takes place at the simulator site of Lufthansa Flight Training company in Frankfurt, Germany. Here, a linkage between a F.I.R.S.T. ATC simulator and several flight simulators has been installed. They are linked by interfaces, host computers and fiber-optic cables, so that data and communication can be exchanged between them. Before the common training could be started, automatic lessons for both flight simulators and radar simulators had to be developed. The contents of these lessons had to be agreed on to assure a positive training effect on both sides. Therefore, an accurate and thorough preparation was necessary. The sessions take place in the same house, allowing controllers and flight crews to meet afterwards for a common debriefing. This is very important, since it is very helpful for flight crews to know about air traffic controllers' work and vice versa. Future developments include signal return from radar simulator to flight simulators in order to trigger TCAS traffic or even visual aid.
Although the system needs significant resources of personnel and administration, it gives the greatest benefit in training quality, concerning the environment of a simulated flight.

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Reference Type: Journal Article
Author: Streiner, D.L.
Year: 2003
Title: Unicorns do exist: A tutorial on "proving" the null hypothesis
Journal: Canadian Journal of Psychiatry
Volume: 48
Issue: 11
Pages: 756-761
Date: December
Keywords: significance testing, equivalence testing, null hypothesis equivalence testing
Abstract: There are times when it is necessary to try to prove the nonexistence of a difference between groups.

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Reference Type: Conference Paper
Author: Sullivan, B. T.; Soukup, P. A.
Year: 1996
Title: The NASA 747-400 flight simulator - A national resource for aviation safety research
Conference Name: AIAA Flight Simulation Technologies Conference
Conference Location: San Diego, CA
Publisher: American Institute of Aeronautics and Astronautics (AIAA)
Date: July 29-31
Electronic Resource Number: AIAA-1996-3517
Author's Title and Affiliation: Barry T. Sullivan: NASA, Ames Research Center, Moffett Field, CA
Paul A. Soukup: NSI Technology Services Corp., Sunnyvale, CA
Number of Pages: 11
Abstract: This paper describes the NASA Ames Research center's Current Technology Glass Cockpit Flight Training Simulator located at Moffett Field, CA. This unique simulator is used to conduct aviation human factors and airspace operations research. The simulator is an exact replica of a cockpit of one of

the most sophisticated and advanced airplanes flying in the world today. Although the simulator replicates a typical flight training simulator, it has unique research capabilities above and beyond the normal training simulator that is used to train today's airline pilots. This paper will describe the NASA simulator and its advanced features, including its unique research capabilities. It will also describe some of the research that has been conducted in the cab since its installation, and will also review some of the upgrades that are currently in progress, or will be conducted in the not too distant future.

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Reference Type: Conference Paper
Author: Sullivan, John M.
Year: 2000
Title: Interactive hybrid environment training
Conference Name: Flight Simulation - The Next Decade
Conference Location: London, UK
Publisher: Royal Aeronautical Society (RAeS)
Date: May 10-12
Author's Title and Affiliation: Squadron Leader, Royal Air Force, Eurofighter Requirements (EFRM4), Defence Procurement Agency, MOD Abby Wood, Bristol
Number of Pages: 8
Abstract: The UK requirement for Eurofighter Typhoon Aircrew Synthetic Training Aids (ASTA) was determined by 2 Training Needs Analyses (TNAs). Subsequent to the conclusion of these comprehensive studies, the doctrine of the UK Armed Forces was fundamentally reviewed to reflect the emerging perception of the military capability demanded by the change in global politics, alliances and attitudes that accompanied the end of the Cold War. Accordingly, an appraisal of the previous TNAs was conducted during 1999, to ensure their continued relevance. In attempting to determine the most appropriate medium with which to address the total training task for EF pilots, it became apparent that there were fundamental limitations in the training that can be delivered by both real and synthetic regimes in isolation. However, a capability to merge these training regimes could mitigate these inherent weaknesses and draw upon the strengths of each to create a holistic training environment.

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Reference Type: Presentations
Author: Summit Aviation
Year: 1999, 1998
Title: Break the paper barrier--Computerized aviation reference library
Type: CD-ROMs
Abstract: (There are too many topics to fit in one field, so A-L are in Abstract and M-Z are in Notes.)
A Hazard in Acrobatics: Effects of G-Forces on Pilots, AC 91-61.
A Model Zoning Ordinance to Limit Height of Objects Around Airports, AC 150/5190-4A.
Acceptable Methods, Techniques, and Practices - Aircraft Alterations, AC 43.13-2A.
Acceptable Methods, Techniques, and Practices - Aircraft Inspection and Repair, AC 43.13-1A.
Accessibility to Excess Emergency Exits, AC 20-60.
Accident/Incident Investigation Procedures, 49 CFR Part 831 (NTSB 831).
The Accident Prevention Counselor Program, AC 60-13.
The Accident Prevention Program - Your Key To Safe Flight, FAA-P-8740-8.
Accident Prevention Program Publications, FAA.
Accidents Resulting from Wheelbarrowing in Tricycle Gear Equipped Aircraft, AC 90-34.
Accounting Records Guide for Airport Aid Program Sponsors, AC 150/5100-10A.
Acrobatics - Precision Flying with a Purpose, AC 91-48.
Active Flight Controls, AC 25.672-1.
Additional Weather Information: Domestic and Flag Air Carriers, AC 121-25.
Address List for Regional Airports Divisions and Airports District/Field Offices, AC 150/5000-3T.
Administrative Claims Under Federal Tort Claims Act, FAR Part 15.
Advanced Qualification Program, AC 120-54.

Advisory Circular Checklist, AC 00-2.11.
Aerodynamics for Naval Aviators.
Aeroelastic Stability Substantiation of Transport Category Airplanes, AC 25.629-1A.
Aeronautical Decision Making, AC 60-22.
Aeronautical Information Manual (AIM) (Formerly Airman's Information Manual)
Agricultural Aircraft Operations, AC 137-1.
Agricultural Aircraft Operations, FAR Part 137.
Aids Authorized for Use by Airman Written Test Applicants, AC 60-11B.
Air Carrier Dispersal Planning Program, AC 120-36A.
Air Carrier First Aid Programs, AC 120-44A.
Air Carrier Internal Evaluation Programs, AC 120-59.
Air Carrier Operational Approval and Use of TCAS II, AC 120-55A.
Air Carrier Regulations, 14 CFR Parts 200 to 399, as designated.
Air Carrier Security, AC 108-1.
Air Traffic Control Handbook, Order 7110.65L.
Air Transportation of Handicapped Persons, AC 120-32.
Air Transportation of Mental Patients, AC 120-34.
Air Transportation Operations Inspector's Handbook (HBAT), Order 8400.10.
Airborne VHF Communications Equipment Installations, AC 20-67B.
Aircraft Arresting System for Joint Civil/Military Airports, AC 150/5220-9.
Aircraft Certification Directorate Procedures, Order 8100.5.
Aircraft Certification Directorates, Order 8000.51.
Aircraft Certification Service Fees for Providing Production Certification-Related Services Outside the United States, AC 187-2.
Aircraft Certification Service Field Office Listing, AC 20-126F.
Aircraft Certification Systems Evaluation Program, AC 21-39.
Aircraft Dispatcher Practical Test Standards, FAA-S-8081-10A (8081-10).
Aircraft Engine Crankshaft Failure, AC 20-103.
Aircraft Engine Type Certification Handbook, AC 33-2B.
Aircraft Fire and Rescue Communications, AC 150/5210-7B.
Aircraft Fire and Rescue Facilities and Extinguishing Agents, AC 150/5210-6C.
Aircraft Fuel Control, AC 20-43C.
Aircraft Fuel Storage, Handling, and Dispensing on Airports, AC 150/5230-4.
Aircraft Ground Handling and Servicing, AC 00-34A.
Aircraft Ice Protection, AC 20-73.
Aircraft Inspection for the General Aviation Aircraft Owner, AC 20-106.
Aircraft Metal Propeller Maintenance, AC 20-37D.
Aircraft Position and Anticollision Light Measurements, AC 20-74.
Aircraft Position Light and Anticollision Light Installation, AC 20-30B.
Aircraft Registration, FAR Part 47.
Aircraft Wake Turbulence, AC 90-23E.
Aircraft Weight and Balance Control, AC 120-27C.
Airframe and Powerplant Mechanics Airframe Handbook, AC 65-15A.
Airframe and Powerplant Mechanics Certification Guide, AC 65-2D.
Airframe and Powerplant Mechanics Certification Information, AC 65-11B.
Airframe and Powerplant Mechanics General Handbook, AC 65-9A.
Airframe and Powerplant Mechanics Powerplant Handbook, AC 65-12A.
Airline Transport Pilot and Aircraft Type Rating Practical Test Standards for Airplane, FAA-S-8081-5C (8081-5).
Airline Transport Pilot and Aircraft Type Rating Practical Test Standards for Helicopter, FAA-S-8081-20 (8081-20).
Airline Transport Pilot, Aircraft Dispatcher, and Flight Navigator Knowledge Test Guide, AC 61-113.
Airline Transport Pilot and/or Type Rating Practical Test Standards, FAA-S-8081-5B. See FAA-S-8081-5C, Airline Transport Pilot and Aircraft Type Rating Practical Test Standards for Airplane.
Airman Medical Record Transmittal (FAA Form 8500-16), Order 8065.2A.
Airman's Information Manual (AIM), Now known as the Aeronautical Information Manual.

Airplane Flight Manual, AC 25.1581-1.
Airplane Flight Manuals (AFM), Approved Manual Materials, Markings, and Placards - Airplanes, AC 60-6B.
Airplane Flight Training Device Qualification, AC 120-45A.
Airplane Operator Security, FAR Part 108.
Airplane Simulator Qualification, AC 120-40B.
Airport Aid Program, FAR Part 152.
Airport Capacity and Delay, AC 150/5060-5.
Airport Certification Manual (ACM) and Airport Certification Specifications (ACS), AC 139.201-1.
Airport Compliance Requirements, Order 5190.6A.
Airport Design, AC 150/5300-13.
Airport Drainage, AC 150/5320-5B.
Airport Emergency Medical Facilities and Services, AC 150/5210-2A.
Airport Emergency Plan, AC 150/5200-31.
Airport Fire and Rescue Personnel Protective Clothing, AC 150/5210-14A.
Airport Improvement Program Grant Assurance Number One - General Federal Requirements, AC 150/5100-16A.
Airport Landscaping for Noise Control Purposes, AC 150/5320-14.
Airport Lighting Equipment Certification Program, AC 150/5345-53A.
Airport Master Plans, AC 150/5070-6A.
Airport Miscellaneous Lighting Visual Aids, AC 150/5340-21.
Airport Noise Compatibility Planning, FAR Part 150.
Airport Pavement Design and Evaluation, AC 150/5320-6D.
Airport Pavement Design for the Boeing 777 Airplane, AC 150/5320-16.
Airport Rescue and Firefighting Station Building Design, AC 150/5210-15.
Airport Safety Self-Inspection, AC 150/5200-18B.
Airport Security, FAR Part 107.
Airport Signing and Graphics, AC 150/5360-12A.
Airport Snow and Ice Control Equipment, AC 150/5220-20.
Airport Winter Safety and Operations, AC 150/5200-30A.
Airports - Required Data, AC 121-26.
Airspace Utilization Considerations in the Proposed Construction, Alteration, Activation and Deactivation of Airports, AC 70-2E.
Air-to-Ground Radio Control of Airport Lighting Systems, AC 150/5340-27A.
Airworthiness and Operational Approval of Airborne Systems to be Used in Lieu of Ground Proximity Warning System (GWPS), AC 20-112.
Airworthiness and Operational Approval of Traffic Alert and Collision Avoidance Systems (TCAS II) and Mode S Transponders, AC 20-131A.
Airworthiness Approval of Airborne Loran-C Navigation Systems for Use in the U.S. National Airspace System (NAS), AC 20-121A.
Airworthiness Approval of Global Positioning System (GPS) Navigation Equipment for use as a VFR and IFR Supplemental Navigation System, AC 20-138.
Airworthiness Approval of Navigation or Flight Management Systems Integrating Multiple Navigation Sensors, AC 20-130A.
Airworthiness Approval of Omega/VLF Navigation Systems for the United States NAS and Alaska, AC 20-101C.
Airworthiness Approval of Vertical Navigation (VNAV) Systems for use in the U.S. NAS and Alaska, AC 20-129.
Airworthiness Certification of Aircraft and Related Products, Order 8130.2C.
Airworthiness Certification of Civil Aircraft Engine, Propellers, and Related Products, AC 21-23.
Airworthiness Certification of U.S. Produced Aircraft and Engine Kits Assembled Outside the United States, AC 21-28.
Airworthiness Criteria for the Approval of Airborne Windshear Warning Systems in Transport Category Airplanes, AC 25-12.
Airworthiness Designee Function Codes and Consolidated Directory for DMIR/DAR/ODAR/DAS/DOA and SFAR No. 36, AC 183-35G.

Airworthiness Designee Management Program, Order 8130.28.
Airworthiness Directives.
Airworthiness Directives, AC 39-7C.
Airworthiness Directives, FAR Part 39.
Airworthiness Inspector's Handbook (HBAW), Order 8300.10.
Airworthiness Standards: Aircraft Engines, FAR Part 33.
Airworthiness Standards: Manned Free Balloons, FAR Part 31.
Airworthiness Standards: Normal Category Rotorcraft, FAR Part 27.
Airworthiness Standards: Normal, Utility, Acrobatic, and Commuter Category Airplanes, FAR Part 23.
Airworthiness Standards: Propellers, FAR Part 35.
Airworthiness Standards: Transport Category Airplanes, FAR Part 25.
Airworthiness Standards: Transport Category Rotorcraft, FAR Part 29.
All About Fuel, FAA-P-8740-35A.
Altimeter and Static System Tests and Inspections, AC 43-203B.
Altimeter Setting Sources, AC 91-14D.
Altitude Alerting Devices/Systems, AC 91-22A.
Always Leave Yourself an Out, FAA-P-8740-25.
Amateur-Built Aircraft and Ultralight Flight Testing Handbook, AC 90-89A.
Amendment of Federal Aviation Regulation Part 171 (FAR 171) - Cost of Flight and Ground Inspections, AC 170-11.
Americans with Disabilities Act.
Anatomy of a Landing - Cue by Cue, FAA-P-8740-26.
Announcement of Availability - A Series of Aeronautical Decision Making Training Manuals, AC 60-21.
Announcement of Availability - Aircraft, Aircraft Engines, and Propeller Type Certificate Data Sheets and Specifications, AC 21-15K.
Announcement of Availability - FAA-S-8081-10A (8081-10), Aircraft Dispatcher Practical Test Standards, AC 61-121.
Announcement of Availability - FAA-S-8081-5C, Airline Transport Pilot and Aircraft Type Rating Practical Test Standards for Airplane.
Announcement of Availability - Airport Land-slide Simulation Model (ALSIM), AC 150/5360-10.
Announcement of Availability - Airport Research and Technical Reports, AC 150/5000-4B.
Announcement of Availability - All Cargo Carrier Activity Report (FAA Form 5100-108, Revised), AC 150/5000-11.
Announcement of Availability - Bird Strike Incident/Ingestion Report, AC 150/5200-32.
Announcement of Availability - Changes to Practical Test Standards, AC 60-27.
Announcement of Availability - FAA-S-8081-6A, Flight Instructor Practical Test Standards for Airplane (Single-Engine and Multiengine) - with Change 1, dated 4/13/98, AC 61-128.
Announcement of Availability - FAA-S-8081-12, {See FAA-S-8081-12A}, Commercial Pilot Practical Test Standards (Airplane), AC 61-110.
Announcement of Availability - Commercial Pilot Practical Test Standards: FAA-S-8081-18 and FAA-S-8081-12A, AC 61-125.
Announcement of Availability - FAA-S-8081-19, Recreational Pilot Powered Parachute Practical Test Standard, AC 61-127.
Announcement of Availability - FAA Order 8130.21A, Procedures for Completion and Use of FAA Form 8130, Airworthiness Approval Tag, AC 00-55.
Announcement of Availability - Flight Standards Service Airman Testing and Training Information, AC 60-26A.
Announcement of Availability - Industry-Developed Transition Training Guidelines for High Performance Aircraft, AC 61-103.
Announcement of Availability - FAA-S-8081-4B (8081-4), Instrument Rating Practical Test Standards, AC 61-111.
Announcement of Availability - List of Air Carriers Certificated by Title 14 of the Code of Federal Regulations (14 CFR) Part 135, AC 135-13F.
Announcement of Availability - Micro-Paver, Pavement Management System, AC 150/5000-6.
Announcement of Availability - National Fire Protection Association (NFPA) Aircraft Familiarization Charts Manual, AC 5210-20.

Aviation Careers Series
Aviation Instructor's Handbook, AC 60-14.
Aviation Insurance, FAR Part 198.
Aviation Maintenance Alerts, AC 43-16A.
Aviation Maintenance Technician Awards Program, AC 65-25A.
Aviation Maintenance Technician Schools, FAR Part 147.
Aviation Mechanic General, Powerplant, and Airframe Knowledge Test Guide, AC 65-28.
Aviation Medical Examiner System, Order 8520.2D.
Aviation Safety Action Programs (ASAP), AC 120-66.
Aviation Safety Inspector Work site Access, AC 13-1.
Aviation Safety Reporting Program, AC 00-46D.
Aviation Security - Acceptance and Handling Procedures Indirect Air Carrier Security, AC 109-1.
Aviation Security - Airports, AC 107-1.
Aviation Security: Air Taxi Commercial Operators (ATCO), AC 135-4A.
Aviation Weather, AC 00-6A.
Aviation Weather Services, AC 00-45D.
Avoiding or Minimizing Encounters With Aircraft Equipped With Depleted Uranium Balance Weights During Accident Investigations, AC 20-123.
Balloon Safety Tips - False Lift, Shear & Rotors, FAA-P-8740-39.
Basic Helicopter Handbook, AC 61-13B.
Bilateral Airworthiness Agreements, AC 21-18.
Buildings For Storage and Maintenance of Airport Snow and Ice Control Equipment and Materials, AC 150/5220-18.
Cabin Pressurization Systems in Small Airplanes, AC 23.841-1.
Canceling or Closing Flight Plans, AC 91.83-1B.
Carbon Monoxide (CO) Contamination in Aircraft - Detection and Prevention, AC 20-32B.
Carriage of Cargo in Restricted Category Aircraft and Other Special Purpose Operations, AC 21-17.
Carry on Baggage, AC 121-29A.
Category II Operations - General Aviation Airplanes, AC 91-16.
Certification: Air Carriers and Commercial Operators, FAR Part 119.
Certification: Airmen Other Than Flight Crewmembers, FAR Part 65.
Certification and Operation of Amateur-Built Aircraft, AC 20-27D.
Certification and Operation of Aviation Maintenance Technician Schools, AC 147-3.
Certification and Operations: Airplanes having a seating capacity of 20 or more passengers or a maximum payload capacity of 6,000 pounds or more., FAR Part 125.
Certification and Operations: Land Airports Serving Certain Air Carriers, FAR Part 139.
Certification: Flight Crewmembers other than Pilots, FAR Part 63.
Certification Maintenance Requirements, AC 25-19.
Certification of a Repairman (General), AC 65-24.
Certification of Air Carriers, AC 120-49.
Certification of Normal Category Rotorcraft, AC 27-1.
Certification of Part 23 Airplanes for Flight in Icing Conditions, AC 23.1419-2.
Certification of Repairmen (Experimental Aircraft Builders), AC 65-23A.
Certification: Pilot and Flight Instructors, AC 61-65C.
Certification: Pilots and Flight Instructors, Old FAR Part 61, effective before Aug. 4, 1997.
Certification: Pilots, Flight Instructors, and Ground Instructors, New FAR Part 61.
Certification Procedures for Products and Parts, AC 21.303-1A.
Certification Procedures for Products and Parts, FAR Part 21.
Charles Taylor "Master Mechanic" Award, AC 65-26A.
Circuit Protective Device Accessibility, AC 25.1357-1.
Circuit Selector Switch, AC 150/5345-5A.
Citizen Participation in Airport Planning, AC 150/5050-4.
Civil Air Patrol and State and Regional Defense Airlift Relationships, AC 00-32A.
Civil Rights Requirements For The Airport Improvement Program (AIP), AC 150/5100-15A.
Civil Utilization of Global Positioning System (GPS), Order 8260.38A.
Cockpit Noise and Speech Interference Between Crewmembers, AC 20-133.

Cockpit Voice Recorder Installations, AC 25.1457-1A.
Code of Federal Regulations
See Title 14, Code of Federal Regulations.
See Title 49, Code of Federal Regulations.
Cold Weather Operation of Aircraft, AC 91-13C.
Commercial Assistance During Construction of Amateur-Built Aircraft, AC 20-139.
Commercial Pilot Knowledge Test Guide, AC 61-114.
Commercial Pilot Practical Test Standards for Airplane, FAA-S-8081-12A (8081-12).
Commercial Pilot Practical Test Standards for Lighter-than-Air (Balloon/Airship), FAA-S-8081-18 (8081-18).
Commercial Pilot Practical Test Standards for Rotorcraft, Helicopter, and Gyroplane, FAA-S-8081-16 (8081-16).
Commercial Space Transportation, FAA, DoT (14 CFR Parts 400 to 499, as designated).
Communication and Coordination Between Flight Crewmembers and Flight Attendants, AC 120-48.
Communication Interference Caused By Unintentional Keyed Microphones, AC 20-111.
Compliance and Enforcement Program, Order 2150.3A.
Composite Aircraft Structure, AC 20-107A.
Composite Propeller Blade Fatigue Substantiation, AC 35.37-1.
Computer Generated/Stored Records, AC 21-35.
Conserving Energy in Flight Instruction, FAA-P-8740-28.
Conspicuity of Aircraft Instrument Malfunction Indicators, AC 20-69.
Construction Progress and Inspection Report Airports Grant Program, AC 150/5370-6B.
The Continued Airworthiness of Older Airplanes, AC 91-60.
Continuing Structural Integrity Program for Large Transport Category Airplanes, AC 91-56A.
Continuous Airworthiness Maintenance Programs, AC 120-16C.
Control of Parts Shipped Prior to Type Certificate Issuance, AC 21-32A.
Control System Locks, AC 23.679-1.
Control System Operations Test, AC 23.683-1.
Conversion of the Inspection Authorization Knowledge Tests to the Computer Based Airmen Knowledge Testing Program, AC 65-29.
Conversion to the Computer Based Airmen Knowledge Testing Program, AC 60-23.
Corrosion Control for Aircraft, AC 43-4A.
Crew Qualification and Pilot Type Rating Requirements for Transport Category Aircraft Operated Under FAR Part 121, AC 120-53.
Crew Resource Management Training, AC 120-51B.
Crewmember Training on Inflight Radiation Exposure, AC 120-61.
Criteria for Acceptance of Ownership and Servicing of Civil Aviation Interest(s) Navigational and Air Traffic Control Systems and Equipment, AC 170-9.
Criteria for Approval of Category III Landing Weather Minima, AC 120-28C.
Criteria for Approving Category I and Category II Landing Minima for FAR 121 Operators, AC 120-29.
Criteria For Operational Approval of Airborne Wind Shear Alerting and Flight Guidance Systems, AC 120-41.
Criteria for Operational Approval of Auto Flight Guidance Systems, AC 120-67.
Currency and Additional Qualification Requirements for Certificated Pilots, AC 61-98A.
Cutouts in a Modified Fuselage of Small Airplanes, AC 23-5.
Daily Body Rhythms, Jet Lag, and Flight Safety, FAA-P-8740-46.
Damage Tolerance and Fatigue Evaluation of Structure, AC 25.571-1C.
Data Base Standardization for the Global Positioning System (GPS) Overlay Program, AC 97-2.
Dead Reckoning Navigation, FAA-P-8740-22.
Debris Hazards at Civil Airports, AC 150/5380-5B.
Definitions and Abbreviations, FAR Part 1.
Definitions of "U.S. National Aviation Standards", AC 00-26.
Density Altitude, FAA-P-8740-2.
Descent to the MDA and Beyond, FAA-P-8740-9.
Design Considerations Concerning the use of Titanium in Aircraft Turbine Engines, AC 33-4.

Design Considerations for Minimizing Hazards Caused by Uncontained Turbine Engine and Auxiliary Power Unit Rotor Failure, AC 20-128A.
Design Considerations to Protect Fuel Systems During a Wheel-Up Landing, AC 25.994-1.
Design Dive Speed, AC 25.335-1.
Design of Aircraft Deicing Facilities, AC 150/5300-14.
Design Standards for an Aircraft Rescue and Fire fighting Training Facility, AC 150/5220-17A.
Designated Alteration Station Authorization Procedures, AC 21.431-1A.
Designated Engineering Representatives, AC 183.29-1FF.
Designated Engineering Representatives (DER) Guidance Handbook, Order 8110.37B.
Designated U.S. International Airports, AC 150/5000-5C.
Designation of Class A, Class B, Class C, Class D, and Class E Airspace Areas; Airways; Routes; and Reporting Points, FAR Part 71.
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Technical Information Regarding Civil Aeronautics Manuals 1, 3, 4a, 4b, 5, 6, 7, 8, 9, 13 and 14, AC 20-33B.
Temporary Flight Restrictions (TFR), AC 91-63B.
Test Procedures for Maximum Allowable Airspeed Indicators, AC 20-134.
Testimony by Employees and Production of Records in Legal Proceedings, and Service of Legal Process and Pleadings, FAR Part 185.

Thunderstorms, AC 00-24B.
Thunderstorms - Don't Flirt ... Skirt 'Em, FAA-P-8740-12.
Tie-Down Sense, AC 20-35C.
Time In Your Tanks, FAA-P-8740-3.
Tips On Winter Flying, FAA-P-8740-24.
Title 14, Code of Federal Regulations (14 CFR)
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14 CFR Preambles, selected.
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Title 49, United States Code (49 USC).
Traffic Advisory Practices at Airports Without Operating Control Towers, AC 90-42F.
Training Centers, FAR Part 142.
Transport Airplane Cabin Interiors Crashworthiness Handbook, AC 25-17.
Transport Category Airplane Electronic Display Systems, AC 25-11.
Transport Category Airplanes Cabin Ozone Concentrations, AC 120-38.
Transport Category Airplanes Modified for Cargo Service, AC 25-18.
Tundra Tires, AC 23.733-1.
Turbine and Compressor Rotors Type Certification Substantiation Procedures, AC 33-3.
Turbine Engine Continued Rotation and Rotor Locking, AC 33.74/92.
Turbine Engine Rotor Blade Containment/Durability, AC 33-5.
Turbine Engine Vibration Survey, AC 33.83.
Turbine-Engine Foreign Object Ingestion and Rotor Blade Containment Type Certification Procedures, AC 33-1B.
Truth in Leasing, AC 91-37A.
Type Certificate Data Sheets (TCDS) and Specifications, Volume I - Single-Engine Airplanes.
Type Certificate Data Sheets (TCDS) and Specifications, Volume II - Small Multiengine Airplanes.
Type Certificate Data Sheets (TCDS) and Specifications, Volume III - Large Multiengine Airplanes.
Type Certificate Data Sheets (TCDS) and Specifications, Volume IV - Rotorcraft, Gliders, Balloons and Airships.
Type Certificate Data Sheets (TCDS) and Specifications, Volume V - Aircraft Engines and Propellers.
Type Certificate Data Sheets (TCDS) and Specifications, Volume VI - Aircraft Listing and Aircraft Engine and Propeller Listing (older aircraft models).
Type Certification Airships, AC 21.17-1A.
Type Certification Fixed Wing Gliders (Sailplanes) Including Powered Gliders, AC 21.17-2A.
Type Certification for Conversion from Reciprocating Engine to Turbine Engine-Powered Part 23 Airplanes, AC 23-14.
Type Certification of Automobile Gasoline in Part 23 Airplanes with Reciprocating Engines, AC 23.1521-1B.
Type Certification of Oxygenates and Oxygenated Gasoline Fuels in Part 23 Airplanes with Reciprocating Engines, AC 23.1521-2.
Type Certification of Very Light Airplanes Under FAR 21.17(b), AC 21.17-3.
Type Certification of Very Light Airplanes with Powerplants and Propellers Certificated to Parts 33 and 35 of the Federal Aviation Regulations (FARs), AC 23-11.
Type Certification Process, Order 8110.4A.
Ultralight Vehicle Operations - Airports, ATC, and Weather, AC 103-6.
The Ultralight Vehicle, AC 103-7.
Ultralight Vehicles, FAR Part 103.
Ultrasonic Testing for Aircraft, AC 43-7.
Unanticipated Right Yaw in Helicopters, AC 90-95.
Understanding and Caring for your Gyroscopic Instruments, FAA-P-8740-16.
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United States (U.S.) National Aviation Standard for the VOR/DME/TAC Systems, AC 00-31A.
United States Standard Flight Inspection Manual, Order 8200.1A.
United States Standard for Terminal Instrument Procedures (TERPS), Order 8260.3B.
Unreliable Airspeed Indications, AC 91-43.

Unusable Fuel Test Procedures For Small Airplanes, AC 23.959-1.
U.S. Airworthiness Certificates and Authorizations for Operation of Domestic and Foreign Aircraft, AC 20-65.
Use of Aircraft Fuel Anti-icing Additives, AC 20-29B.
Use of Advanced Training Devices (Airplane Only), AC 120-46A.
Use of Alternate Grades of Aviation Gasoline for Grade 80/87 and Use of Automotive Gasoline, AC 91-33A.
Use of Approach Slope Indicators for Pilot Training, AC 61-47A.
Use of Automobile Gasoline in Agricultural Aircraft, AC 21-21.
Use of CD-ROM Systems, AC 120-69.
Use of Child Seats In Aircraft, AC 91-62A.
Use of Federal Aviation Administration Communications System, FAR Part 189.
Use of Manufacturers' Maintenance Manuals, AC 20-77.
Use of Nondestructive Testing Devices in the Evaluation of Airport Pavements, AC 150/5370-11.
Use of Portable Electronic Devices Aboard Aircraft, AC 91.21-1.
Use of Pyrotechnic Visual Distress Signaling Devices in Aviation, AC 91-58.
Use of Radionavigation Land Test Station and Signal Generators, AC 170-6C.
Use of Shoulder Harness in Passenger Seats, AC 91-65.
Use of Society of Automotive Engineers (SAE) Class H11 bolts, AC 20-127.
Use of Value Engineering for Engineering and Design of Airport Grant Projects, AC 150/5300-15.
Using the System (TCA - TRSA), FAA-P-8740-32.
Vertiport Design, AC 150/5390-3.
VFR Flight Near Noise-Sensitive Areas, AC 91-36C.
Vibration Evaluation of Aircraft Propellers, AC 20-66.
Voluntary Disclosure Reporting Program, AC 00-58.
Voluntary Industry Distributor Accreditation Program, AC 00-56.
VOR Course Errors Resulting from 50 kHz channel Mis-Selection, AC 90-58C.
Waivers of Part 101, Federal Aviation Regulations, AC 101-1A.
Waivers of Provisions of Title 14 of the Code of Federal Regulations Part 91, AC 91-72.
Waivers of Subpart B, Part 91 of the Federal Aviation Regulations (FARs), AC 91-5C.
Waivers: Aviation Events, AC 91-45C.
Washington Headquarters Directives Checklist, Order 0000.4Z.
Waste Water/Potable Water Drain System Certification, AC 25.1455-1.
Water in Aviation Fuels, AC 20-125.
Water Ingestion Testing for Turbine Powered Airplanes, AC 20-124.
Water Rescue Plans, Facilities, and Equipment, AC 150/5210-13A.
Water Supply Systems for Aircraft Fire and Rescue Protection, AC 150/5220-4B.
Water, Slush, and Snow on the Runway, AC 91-6A.
Weight and Balance, FAA-P-8740-5.
Weld Repair of Aluminum Crankcases and Cylinders of Piston Engines, AC 33-6.
What's an Accident Prevention Counselor?, FAA-P-8740-43.
Wind Shear, FAA-P-8740-40.
Your Shoulder Harness, FAA-P-8740-45.

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Reference Type: Magazine Article
Author: Sumwalt, Robert L. III
Year: 2003
Title: Airplane upset recovery training: A line pilot's perspective
Magazine: Flight Safety Digest
Volume: 22
Issue Number: 7-8
Date: July-August
Author's Title and Affiliation: Captain
Keywords: loss of control, upset recovery training (URT), in-flight simulation

Abstract: To reduce loss of control accidents, the U.S. government has funded a program to provide airplane upset-recovery training to 2,000 airline pilots. The training is conducted in an aerobatic single-engine airplane and in a multi-engine jet modified as a variable-stability in-flight simulator.
Notes: in issue Loss of Control: Returning from Beyond the Envelope
URL: http://flightsafety.org/fsd/fsd_jul-aug03.pdf

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Reference Type: Conference Paper
Author: Svensson, E.; Angelborg-Thanderz, M.
Year: 2000
Title: Simulated landings in turbulence--Motion, predictive modeling, and psychometric aspects
Conference Name: Modeling and Simulation Technologies Conference and Exhibit
Conference Location: Denver, CO
Publisher: American Institute of Aeronautics and Astronautics (AIAA)
Date: August 14-17
Electronic Resource Number: AIAA 2000-4076
Author's Title and Affiliation: National Defence Research Establishment (FOA), Linkoping, Sweden
Number of Pages: 11
Abstract: To maintain control in approach/landings under turbulence, the pilot requires prompt attention. The lead provided by non-visual cues is then important. One objective of two studies was to analyze whether a moving base dome simulator could produce more realistic cues than a fixed base simulator. In the first study half of 60 landings were performed with the motion system disengaged. The pilots rated risk, difficulty, workload, performance, handling qualities, and induced oscillations. Stick activity and difficulty were higher and performance lower under the motion condition. In a second study the importance of motion in turbulent landings was verified and analyses of the pilots' control responses showed that there were inter-individual differences. Model analyses showed that turbulence affects workload, and that workload, in its turn, influences performance. We found that handling qualities and induced oscillations could be predicted from the other variables. The variables turbulence and motion of the aircraft explains 65 percent of the variance in handling qualities ratings and 36 percent of the variance in ratings of pilot induced oscillations. Accordingly, handling qualities and pilot induced oscillations can be estimated and predicted in situations 'without man in the loop'. The analyses present psychological aspects related to and underlying aircraft handling qualities and pilot induced oscillations.

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Reference Type: Conference Paper
Author: Symes, Brian
Year: 2000
Title: MSHATF - Delivering military helicopter training in the new millennium
Conference Name: Flight Simulation - The Next Decade
Conference Location: London, UK
Publisher: Royal Aeronautical Society (RAeS)
Date: May 10-12
Author's Title and Affiliation: CAE Aircrew Training Services plc, Wallingford Oxfordshire OX10 6AA England
Number of Pages: 4
Abstract: The UK Ministry of Defense (MoD)'s decision, in October 1997, to award a 40 year Private Finance Initiative contract to CAE Aircrew Training Services plc for the design, construction, management, financing and operation of a purpose-built facility to provide simulator training for RAF Support Helicopter aircrews, marked a new concept for training delivery to the Royal Air Force.
This paper will summarize the rationale and training objectives which underpinned the decision to adopt the Medium Support Helicopter Training Facility (MSHATF) approach. It will provide a flavor of the demanding functional requirements specified for the training facility by the MoD and detail the various elements of the training service, including the 6 Dynamic Mission Simulators and the Tactical Control Center - which makes the MSHATF unique.

It will review progress to date in delivering the contracted training service, consider the potential of the MSHATF and speculate on the extent to which this might be exploited in the future.

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Reference Type: Conference Paper
Author: Szczepanski, Cezary; Leland, Dick
Year: 2000
Title: Move or not to move? Continuous question
Conference Name: AIAA Modeling and Simulation Technologies Conference and Exhibit
Conference Location: Denver, CO
Publisher: American Institute of Aeronautics and Astronautics
Date: August 14-17
Electronic Resource Number: AIAA-2000-4297
Author's Title and Affiliation: Cezary Szczepanski: Ph.D., M.Sc.Eng, Warsaw University of Technology, ETC-PZL Aerospace Industries, Poland
Dick Leland: Environmental Tectonics Corporation, Southampton, PA
Number of Pages: 11
Abstract: The authors' many years experience in design and manufacture of flight simulators, aviation training devices, and ground vehicle simulators have provided extensive understanding regarding the importance of motion systems in simulators. This paper presents our conclusions on the necessity of motion systems in flight training simulators for fixed wing aircraft and helicopters used by the armed forces. Motion system options considered were no motion, less than 6 DoF, and 6 DoF. In preparing the paper, the following factors were considered:

- Type of simulated aircraft
- Range of simulator Usage
- User of the Simulator
- Technological Aspects
- Pilots' Psychological and Physiological needs
- Financial Aspects

Our conclusion is that motion systems are necessary for flight simulation, especially when training flight tasks where motion stimuli are important for the pilot to determine appropriate control inputs. When the simulation only stimulates the pilot visually, there is a great deal of missing information that is normally present in flight and learning transfer is often adversely affected. Pilots should be trained in an appropriate motion system equipped simulator in order not to sacrifice training effectiveness. This is especially essential when pilots are trained for high G tolerance and Spatial Disorientation avoidance.

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Reference Type: Journal Article
Author: Takahashi, Masahiro; Watanuki, Koichi; Ikeda, Takudo
Year: 1999
Title: Sensation and action during active and passive movement
Journal: Acta Otolaryngol (Stockh)
Volume: 119
Issue: 2
Pages: 121-125
Date: March
Author's Title and Affiliation: Department of Otolaryngology, Yamaguchi University School of Medicine, Yamaguchi, Japan
Number of Pages: 5
Keywords: active, Coriolis acceleration, gaze, passive, posture
Abstract: In order to determine the cause of active or passive sensation and action, we studied the effect of perception on gaze and posture control. Normal adults and a patient with bilateral labyrinthine loss underwent whole body rotation seated in a chair (120˚/s) or standing on a platform (60˚/s), while tilting their head with their vision normal or covered. Eye movements were recorded by a CCD video camera and body sways by a force platform. In normal subjects, gaze and posture became ataxic when head tilting with their vision covered, but they remained skilled under conditions of normal vision. The patient with bilateral labyrinthine loss did not undergo the effect of head tilting with no vision. It seems likely that sensation and action, whether they are skilled or ataxic, are controlled by the perception of an outer world which is integrated from visual and vestibular inputs and functions as a vector in the head.
Author Address: Takahashi, Masahiro, Yamaguchi U School of Medicine, Dept of Otolaryngology, 1144 Kogushi Ube, Yamaguchi-ken, Yamaguchi, Japan, 755-8505, masataka@po.cc.yamaguchi-u.ac.jp

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Reference Type: Electronic Article
Author: Talleur, Donald Anders
Year: 2001
Title: Equilibrium and flying: Illusions of flight
Periodical Title: Canadian Owners and Pilots Association (COPA) Pilot Primer
Issue: May
Author's Title and Affiliation: Assistant Chief Flight Instructor, University of Illinois, Institute of Aviation
Keywords: illusions, vestibular system, upset recovery training (URT)
Notes: On July 6, 2007, the web page was no longer available.
URL: http://www.copanational.org/non-members/safety/safetyPPMay01.htm
Access Date: July 26, 2002

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Reference Type: Conference Paper
Author: Talleur, Donald A.; Taylor, Henry L.; Bradshaw, Gary L.; Emanuel, Tom W. Jr.; Rantanen, Esa; Lendrum, Lester; Hulin, Charles L.
Year: 2001
Title: Effectiveness of a personal computer aviation training device (PCATD) for maintaining instrument currency
Conference Name: The Eleventh International Symposium on Aviation Psychology
Conference Location: Columbus, OH: The Ohio State University
Number of Pages: 6
Abstract: This study investigates the potential of personal Computer Aviation Training Devices (PCATDs) to substitute for actual aircraft experience for maintaining instrument currency. A Jeppesen FS-2000 PCATD and a Frasca-141 flight training device (FTD) were tested. The experiment compared the flight performance of four groups after a six-month period between instrument proficiency check (IPC) flights. The control group received no training to maintain currency in this period. Three other groups training in either the PCATD, the Frasca, or the aircraft. Preliminary results for the 106 subjects are presented. The

performance of the subjects on an initial evaluation flight test and a final proficiency flight test six months later were compared. All subjects were instrument current by FAA standards prior to the evaluation flight test. Forty-two percent of the 106 subjects passed the evaluation flight test while 52 percent passed the final test. Results also indicate that the additional training received during the six months had the effect of improving final flight performance as compared to the evaluation flight. In particular, both the PCATD and Frasca FTD subjects were more likely to pass the final proficiency test than the control or aircraft subjects. Poorer performance from the aircraft group was not expected. A detailed analysis of individual maneuvers was also performed in order to determine if a particular method of maintaining currency was better suited for certain maneuvers.

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Reference Type: Conference Proceedings
Author: Tang, Liang; Roemer, Michael; Ge, Jianhua; Crassidis, Agamemnon; Prasad, J. V. R.; Belcastro, Christine
Year of Conference: 2009
Title: Methodologies for adaptive flight envelope estimation and protection
Conference Name: AIAA Guidance, Navigation, and Control Conference
Conference Location: Chicago, IL
Publisher: American Institute of Aeronautics and Astronautics (AIAA)
Pages: 1-14
Date: Aug. 10-13
Electronic Resource Number: AIAA-2009-6260
Author's Title and Affiliation: Tang (Team Leader), Roemer, & Ge: Impact Technologies, LLC, Rochester, NY
Crassidis: Rochester Institute of Technology, Rochester, NY
Prasad: Georgia Institute of Technology, Atlanta, GA
Belcastro: NASA Langley Research Center, Hampton, VA
Number of Pages: 14
Keywords: adaptive flight envelope protection, flight envelope estimation, fault detection, upset recovery training (URT)
Abstract: This paper reports the latest development of several techniques for adaptive flight envelope estimation and protection system for aircraft under damage upset conditions. Through the integration of advanced fault detection algorithms, real-time system identification of the damage/faulted aircraft and flight envelope estimation, real-time decision support can be executed autonomously for improving damage tolerance and flight recoverability. Particularly, a bank of adaptive nonlinear fault detection and isolation estimators were developed for flight control actuator faults; a real-time system identification method was developed for assessing the dynamics and performance limitation of impaired aircraft; online learning neural networks were used to approximate selected aircraft dynamics which were then inverted to estimate command margins. As off-line training of network weights is not required, the method has the advantage of adapting to varying flight conditions and different vehicle configurations. The key benefit of the envelope estimation and protection system is that it allows the aircraft to fly close to its limit boundary by constantly updating the controller command limits during flight. The developed techniques were demonstrated on NASA's Generic Transport Model (GTM) simulation environments with simulated actuator faults. Simulation results and remarks on future work are presented.

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Reference Type: Journal Article
Author: Taylor, Henry L.; Lintern, Gavan
Year: 1993
Title: Quasi-transfer as a predictor of transfer from simulator to airplane
Journal: The Journal of General Psychology
Volume: 120
Issue: 3
Pages: 257-276

Date: July
Author's Title and Affiliation: University of Illinois at Urbana-Champaign, Savoy, IL
Number of Pages: 20
Abstract: Simulators have emerged as important components of flight-training programs. Nevertheless, the development of design principles that can maximize training transfer and cost-benefit trade-offs are not well established. The most significant challenge to research that would bear on simulator design principles is the difficulty and expense of flight transfer experiments. This difficulty and expense can be reduced by the use of an in-simulator transfer design, designated here as a quasi-transfer study, in which transfer is to a high-fidelity configuration of a simulator. Of primary concern for such studies is whether the implied assumption of correspondence between quasi-transfer and transfer effects is well founded. In this article, we review evidence that bears on this issue. The evidence is not entirely supportive but does indicate some correspondence between quasi-transfer and transfer.
URL: http://findarticles.com/p/articles/mi_m2405/is_n3_v120/ai_15204656/print

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Reference Type: Report
Author: Taylor, H. L.; Lintern, G.; Hulin, C. L.; Talleur, D.; Emanuel, T.; Phillips, S.
Year: 1997
Title: Transfer of training effectiveness of personal computer-based aviation training devices
Date: May
Type: Technical Report
Report Number: DOT/FAA/AM-97/11
Author's Title and Affiliation: University of Illinois at Urbana-Champaign, Institute of Aviation, Savoy, IL 61874
Number of Pages: 24
Keywords: personal computer-based aviation training devices, flight training, instrument flight, psychology, applied psychology
Abstract: The training effectiveness of Personal Computer-Based Aviation Training Devices (PCATDs) has received only limited testing. In the experiment reported here, a commercially available PCATD was evaluated in a transfer of training experiment for its effectiveness in supporting instrument flight training. The data show levels of savings in airplane flight time that varied from 15% to over 40% for certain training exercises. However, there were also cases in which savings were essentially zero or even showed decrements as high as 25%. In general, transfer savings were positive and substantial when new tasks were introduced. The data indicate that a PCATD can provide training benefit for certain tasks but, in addition, use of the PCATD in some areas is not expected to result in savings and will erode the overall potential to reduce costs.

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Reference Type: Journal Article
Author: Taylor, Henry L.; Lintern, Gavan; Hulin, Charles L.; Talleur, Donald A.; Emanuel, Jr., Tom W.; Phillips, Sybil I.
Year: 1999
Title: Transfer of training effectiveness of a personal computer aviation training device
Journal: International Journal of Aviation Psychology (IJAP)
Volume: 9
Issue: 4
Pages: 319-335
Number of Pages: 17
Abstract: The training effectiveness of personal computer aviation training devices (PCATDs) has received only limited testing. In the experiment reported here, a commercially available PCATD was evaluated for its transfer effectiveness for teaching of instrument flight skills. Students from the beginning and advanced instrument courses at the University of Illinois were trained to criterion in the PCATD on a wide range of tasks and were then retained to criterion in the airplane on the same tasks. Other students were trained to criterion on the same tasks only in the airplane. Comparisons of trials to criterion in the

airplane for the 2 groups, their times to complete each flight lesson in the airplane, and their course completion times were used to assess the training effectiveness of the PCATD. Transfer savings were generally positive and substantial when new tasks were introduced but low when tasks already learned in previous lessons were reviewed. A comparison of course completion times showed savings of 3.9hr in the airplane for the PCATD group compared to the airplane-control group.

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Reference Type: Report
Author: Taylor, Henry L.; Talleur, Donald A.; Phillips, Sybil I.; Emanuel, Tom W. Jr.; Hulin, Charles L.
Year: 1998
Title: Use of personal computers for instrument training
City: Savoy, IL
Institution: Institution of Aviation, University of Illinois
Type: Research Study
Number of Pages: 14
Abstract: The training effectiveness of Personal Computer Aviation Training Devices (PCATDs) has received only limited testing. This study evaluated a commercially available PCATD to determine its transfer effectiveness for the instruction of instrument skills. In order to evaluate transfer of training, the performance of a group of subjects trained in a PCATD, and later trained to criterion in an aircraft, was compared to the performance of a control group of subjects trained only in the airplane. For the PCATD group, all new maneuvers and procedures were introduced and trained to proficiency in a PCATD prior to training and skill validation in the aircraft. For the Airplane Control group, all new maneuvers were introduced and trained to proficiency in the airplane. Comparisons of trials to criterion in the airplane for the two groups, their times to complete each flight lesson in the airplane, and their course completion times were used to assess the training effectiveness of the PCATD. The data from this study indicates that the PCATD is an effective training device for teaching instrument tasks. Transfer savings were generally positive and substantial when new tasks were introduced but low when tasks already learned in previous lessons were reviewed. A comparison of course completion times showed savings of about four hours in the airplane for the PCATD group compared to the Airplane Control group. The cumulative transfer effectiveness ratio was 0.15 or a saving of 1.5 flight hours for each ten hours of PCATD time.

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Reference Type: Conference Paper
Author: Taylor, Henry L.; Talleur, Donald A.; Rantanen, Esa M.; Emanuel, Tom W. Jr.
Year: 2005
Title: The effectiveness of a personal computer aviation training device (PCATD), a flight training device (FTD), and an airplane in conducting instrument proficiency checks
Conference Name: 13th International Symposium on Aviation Psychology
Conference Location: Dayton, OH
Author's Title and Affiliation: University of Illinois at Urbana-Champaign Institute of Aviation
Number of Pages: 5
Abstract: This project evaluated the effectiveness of a personal computer aviation training device (PCATD), a flight training device (FTD) and an airplane for conducting an instrument proficiency check (IPC). The study compared the performance of pilots receiving an IPC in a PCATD, in an FTD and in an airplane (IPC #1) with performance on a later IPC in an airplane (IPC #2). Chi-square tests were used to analyze the IPC #1 and IPC #2 data to determine whether the treatment (assignment to group) had an effect on the pass/fail ratio for the IPC #1 and IPC #2 flights respectively. The treatment effect on the IPC #1 and IPC #2 pass/fail ratios were not statistically significant. A series of planned-comparison tests were performed both between the experimental groups and between subjects within each experimental group. The PCATD group was compared to the Airplane group and to the FTD group, the Airplane group to the FTD group. None of these comparisons showed statistically significant (a < .05) differences between groups. These findings provide compelling evidence for permitting the use of PCATDs to give IPCs.
URL: http://www.humanfactors.uiuc.edu/Reports&PapersPDFs/isap05/taytalranemaavpsy05.pdf

Reference Type: Web Page
Author: Technical Cooperation Program (TTCP)
Year: 2006
Title: Simulation evaluation
Access Year: 2007
Access Date: Feb. 5
Description: Website
Number of Pages: 5
Abstract: -What types of simulations are available?
-What is advanced/distributed distance learning (ADL)?
-How do you determine the effectiveness of representations?
-How do I measure simulator fidelity?
-What is the relationship between fidelity and training effectiveness?
URL: http://trainingsystems.org/TTCP/html/evaluation_simulation/simulation_eval.html

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Reference Type: Magazine Article
Author: Tegtmeier, Lee Ann
Year: 2006
Title: Retooling maintenance lessons
Magazine: Aviation Week & Space Technology
Pages: 50
Date: December 4
Type of Article: part of section on Simulation and Training
Number of Pages: 1
Abstract: Training industry considers moving from 'chalk and talk' to simulators.
Notes: Part of section on Simulation and Training. All articles in this section include:
Fighting human error (F. Fiorino)
Retooling maintenance lessons (L. A. Tegtmeier)
Getting upset (E. H. Phillips)
A little competition (J. C. Anselmo)
Ready, VLJet, go (F. Fiorino)

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Reference Type: Conference Proceedings
Author: Telban, Robert J.; Cardullo, Frank M.; Houck, Jacob A.
Year of Conference: 1999
Title: Developments in human centered cueing algorithms for control of flight simulator motion systems
Conference Name: AIAA Modeling and Simulation Technologies Conference and Exhibit
Conference Location: Portland, OR
Publisher: American Institute of Aeronautics and Astronautics (AIAA)
Volume: Collection of Technical Papers (A99-36794 09-54)
Date: August 9-11
Electronic Resource Number: AIAA-1999-4328
Author's Title and Affiliation: Telban & Cardullo: New York, State Univ., Binghamton
Houck: NASA, Langley Research Center, Hampton, VA
Number of Pages: 11
Abstract: The authors conducted further research with cueing algorithms for control of flight simulator motion systems. A variation of the so-called optimal algorithm was formulated using simulated aircraft angular velocity input as a basis. Models of the human vestibular sensation system, i.e. the semicircular canals and otoliths, are incorporated within the algorithm. Comparisons of angular velocity cueing responses showed a significant improvement over a formulation using angular acceleration input. Results also compared favorably with the coordinated adaptive washout algorithm, yielding similar results for angular velocity cues while eliminating false cues and reducing the tilt rate for longitudinal cues. These

results were confirmed in piloted tests on the current motion system at NASA-Langley, the Visual Motion Simulator (VMS). Proposed future developments by the authors in cueing algorithms are revealed. The new motion system, the Cockpit Motion Facility (CMF), where the final evaluation of the cueing algorithms will be conducted, is also described.

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Reference Type: Conference Proceedings
Author: Teufel, H.J.; Nusseck, H.-G.; Beykirch, K.A.; Butler, J.S.; Kerger, M.; Bülthoff, H.H.
Year of Conference: 2007
Title: MPI motion simulator: Development and analysis of a novel motion simulator
Conference Name: AIAA Modeling and Simulation Technologies Conference and Exhibit
Conference Location: Hilton Head, SC
Publisher: American Institute of Aeronautics and Astronautics (AIAA)
Date: August 20-23
Electronic Resource Number: AIAA 2007-6476
Author's Title and Affiliation: Teufel: Research Assistant
Nusseck: VR-System Administrator
Beykirch: Research Scientist
Butler: Research Scientist
Kerger: VR Administrator
Bülthoff: Director, Department Bülthoff
Max Planck Institute for Biological Cybernetics, Department Bülthoff, Spemannstraße 44, 72076, Tübingen, Germany
Abstract: This paper discusses the technical issues that were required to adapt a KUKA Robocoaster for use as a real-time motion simulator. Within this context, the paper addresses the physical modifications and the software control structure that were needed to have a flexible and safe experimental setup. It also addresses the delays and transfer function of the system. The paper is divided into two sections.
The first section describes the control and safety structures of the MPI Motion Simulator. The second section shows measurements of latencies and frequency response of the motion simulator. The results show that the frequency responses of the MPI Motion Simulator compare favorably with high-end Stewart Platforms, and therefore demonstrate the suitability of robot-based motion simulators for flight simulation.

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Reference Type: Conference Proceedings
Author: Tomlin, Claire; Lygeros, John; Sastry, Shankar
Year of Conference: 1998
Title: Aerodynamic envelope protection using hybrid control
Conference Name: American Control Conference
Conference Location: Philadelphia, PA
Date: June 24-26
Author's Title and Affiliation: Department of Electrical Engineering and Computer Sciences, University of California, Berkeley, CA
Keywords: envelope protection, upset recovery training (URT)
Abstract: This paper presents the application of controller thesis for hybrid systems to aerodynamic envelope protection and safe switching between flight modes. Each flight mode, which describes a configuration of the dynamic equations describing the motion of the aircraft, is treated as a discrete state with associated continuous, nonlinear dynamics and the safe subset of the state space (that which ensures aerodynamic envelope protection) is calculated for each discrete state. The methodology is applied to a longitudinal axis model of a CTOL aircraft.
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lygeros@eecs.berkeley.edu
sastry@eecs.berkeley.edu

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Reference Type: Conference Paper
Author: Tomlinson, B. N.
Year: 1985
Title: Simulator motion characteristics and perceptual fidelity
Conference Name: Flight Mechanics Panel Symposium on Flight Simulation
Conference Location: Cambridge, United Kingdom
Publisher: Advisory Group for Aerospace Research and Development (AGARD)
Date: September 30 - October 3
Author's Title and Affiliation: FS(B)3 Division, Royal Aircraft Establishment, Bedford MK41 6AE, United Kingdom
Number of Pages: 12
Keywords: perceptual fidelity, motion characteristics, cue generation
Abstract: This paper is a progress report on a study, commissioned by the AGARD Flight Mechanics Panel, to review existing data and try to describe a relationship between certain motion systems parameters, identified in an earlier AGARD report (AR-144), and the fidelity of the pilot's perception of flight. Motion systems characteristics as a whole are discussed, this extending AR-144's treatment of motion mechanisms to include motion drive software and other features. Some of the key parameters of AR-144 are then examined in relation to total motion system fidelity. Finally, some proposals are made of a common format data structure with which to summarize research results on motion cues. The study is continuing.
Notes: Published in September 1986.

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Reference Type: Conference Paper
Author: Tomlinson, David
Year: 2003
Title: Voice recognition in an air traffic control simulation environment
Conference Name: Simulation of the Environment
Conference Location: London, UK
Publisher: Royal Aeronautical Society (RAeS)
Date: 2003
Number of Pages: 5

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Reference Type: Conference Paper
Author: Tran, Duc; Hernandez, Estela
Year: 2004
Title: Use of the vertical motion simulator in support of the American Airlines flight 587 accident investigation
Conference Name: AIAA Modeling and Simulation Technologies Conference and Exhibit
Conference Location: Providence, RI
Publisher: American Institute of Aeronautics and Astronautics (AIAA)
Date: August 16-19
Electronic Resource Number: AIAA 2004-5032
Author's Title and Affiliation: Tran: Aerospace Engineer, Aerospace Simulation Operations Branch, M/S 243-5, NASA Ames Research Center, Moffett Field, CA 94035
Hernandez: Simulation Engineer, Northrop Grumman Information Technology, M/S 243-6, Moffett Field, CA 94035
Number of Pages: 7
Keywords: vertical motion simulator (VMS), American Airlines flight 587, upset recovery training (URT)
Abstract: As part of the investigation of the accident involving American Airlines Flight 587, the National Transportation Safety Board (NTSB), in cooperation with NASA Ames Research Center, proposed to conduct observations and tests using the Vertical Motion Simulator (VMS). The investigation was divided

into two phases. Phase I consisted of evaluating the accelerations experienced during the accident event by back-driving the cockpit controls, displays, out of the window scene, cockpit communications, and motion of the aircraft as recorded and derived from the aircraft's flight data recorder (FDR) and cockpit voice recorder (CVR). Phase II consisted of evaluating the effects of flight control characteristics and accelerations similar to those experienced during the accident event on pilot perception and performance using a tracking task. The tracking task consisted of pilots following an on-screen target with various flight control configurations, with both motion off and motion being back-driven using derived acceleration data from the FDR. This paper describes the work provided by the VMS in support of the investigation and does not include any conclusions drawn from the study.

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Reference Type: Journal Article
Author: Treisman, Michel
Year: 1977
Title: Motion sickness: An evolutionary hypothesis
Journal: Science
Volume: 197
Issue: July
Pages: 493-495
Author's Title and Affiliation: University of Oxford, Department of Experimental Psychology, South Parks Road, Oxford, England OX13UD
Number of Pages: 3
Abstract: Since the occurrence of vomiting as a response to motion is both wide-spread and apparently disadvantageous, it presents a problem for evolutionary theory. A hypothesis is proposed suggesting that motion sickness is triggered by difficulties which arise in the programming of movements in the eyes or head when the relations between the spatial frameworks defined by the visual, vestibular, or proprioceptive inputs are repeatedly and unpredictably perturbed. Such perturbations may be produced by certain types of motion, or by disturbances in sensory input or motor control produced by ingested toxins. The last would be the important cause in nature, the main function of the emesis being to rid the individual of ingested neurotoxins. Its occurrence in response to motion would be an accidental by-product of this system.

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Reference Type: Journal Article
Author: Tribukait, Arne
Year: 2006
Title: Subjective visual horizontal in the upright posture and asymmetry in roll-tilt perception: Independent measures of vestibular function
Journal: Journal of Vestibular Research
Volume: 16
Issue: 1-2
Pages: 35-43
Author's Title and Affiliation: Department of Audiology, Karalinska Hospital, SE 171 76 Stockholm, Sweden
Number of Pages: 10
Keywords: vestibular, labyrinth, otolith, utricle, semicircular canal
Abstract: The subjective visual horizontal (SVH) was measured in the upright position and at 10, 20, and 30 degrees of head and body tilt to the right and left. Normal subjects (n = 25) were tested on two separate occasions with an interval of 1-14 days. Test variables considered were the SVH in the upright position, the perception of tilt to the right and left, calculated on the basis of the SVH in the upright and tilted positions, and the asymmetry in tilt perception. There was no correlation between the perception of tilt to the right and to the left (r = 0.10). Neither was there any correlation between the SVH in the upright position, representing a resting asymmetry, and the asymmetry in tilt perception, i.e. the response asymmetry (r = 0.17). However, for each variable, there was a high correspondence between data

obtained at test and retest (r ranged from 0.68 to 0.89, $p < 0.001$), suggesting that the independence between variables is not due to noise. Findings are discussed taking into consideration the possible roles of otoliths and semicircular canals in the formation of SVH. In an attempt to explain the independence between the two measures of asymmetry it is hypothesized that while the otoliths must be essential for the perception of static lateral tilt, the SVH in the upright position to a considerable degree reflects semicircular canal function.
Author Address: Swedish Defence Research Agency, Berzelius väg 13, Karolinska Institutet, SE 171 77 Stockholm, Sweden. Tel: +46 08 52486348; Fax: +46 08 330923; E-mail: arne.tribukait@foi.se

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Reference Type: Journal Article
Author: Tropper, Karin; Kallus, K. Wolfgang; Boucsein, Wolfram
Year: 2009
Title: Psychophysiological evaluation of an antidisorientation training for visual flight rules pilots in a moving base simulator
Journal: International Journal of Aviation Psychology
Volume: 19
Issue: 3
Pages: 270-286
Date: July
Number of Pages: 17
Accession Number: 01138178
Keywords: air pilots, evaluation, flight simulators, training, visual flight
Abstract: Spatial disorientation following inadvertent flight from visual into instrument meteorlogical conditions is a frequent cause of fatal accidents in visual flight rules (VFR) rated pilots. Three groups of VFR pilots who underwent different training conditions were compared in a motion base simulator. Test profiles consisted of a flight in deteriorating weather with the possibility of entering clouds and recovering from unusual attitudes. Flight performance and psychophysiological concomitants of anxiety and stress were recorded. During the final test, the group with specialized antidisorientation training performed better and showed less psychophysiological stress during complex recovery maneuvers compared to the other 2 groups.

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Reference Type: Book
Author: Tsang, Pamela S.; Vidulich, Michael A.
Year: 2003
Title: Principles and practice of aviation psychology
City: Mahwah, NJ
Publisher: Lawrence Erlbaum Associates, Inc., Publishers
URL: http://books.google.com/books?id=0QgLki-QrkgC&pg=PA159&lpg=PA159&dq=Burki-Cohen&source=bl&ots=6XwRzb1kc3&sig=MXzmoHirt4kXWpgKHuv30jpWwNM&hl=en&ei=XHBtTN_QFsGclgf8zKTSDQ&sa=X&oi=book_result&ct=result&resnum=10&ved=0CFEQ6AEwCTge#v=onepage&q=Burki-Cohen&f=false

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Reference Type: Conference Paper
Author: Tuxill, Bruce
Year: 2000
Title: United States perspective on long range training requirements
Conference Name: RAeS International Conference - Flight Simulation
Date: May 10-12
Notes: This is the text of a presentation given

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Reference Type: Report
Author: U.S. Department of Transportation
Year: 1989
Title: Cockpit human factors research requirements
City: Cambridge, MA 02142
Institution: Research and Special Programs Administration
Date: April
Number of Pages: 59

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Reference Type: Report
Author: U.S. Department of Transportation/Federal Aviation Administration
Year: 2004
Title: FSD ARC Recommendations of Part 60 Notice of Proposed Rulemaking
Series Title: Docket Management System
City: Washington, DC
Date: February 3
Report Number: FAA-2002-12461-84
URL: http://dmses.dot.gov/docimages/pdf88/267911_web.pdf

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Reference Type: Report
Author: U.S. Department of Transportation/Federal Aviation Administration
Year: 2006
Title: Flight simulation training device initial and continuing qualification and use; Final rule
Document Number: Docket No. FAA–2002–12461
Date: October 30
Alternate Title: Part 60
Report Number: 14 CFR Part 60
Abstract: The FAA is amending the regulations to establish a new part to set forth qualification requirements for flight simulation training devices (FSTD). The new part consolidates and updates FSTD requirements that currently exist in different parts of the FAA's regulations and in advisory circulars. In addition, the FAA is requiring that sponsors of FSTDs have a Quality Management System. These changes are necessary to promote standardization and accountability for FSTD qualification, maintenance, and evaluation. The intended effect of the new part is to ensure that users of FSTDs receive training in devices that closely match the performance and handling characteristics of the aircraft being simulated.
URL: http://dmses.dot.gov/docimages/p88/431747.pdf

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Reference Type: Web Page
Author: U.S. Environmental Protection Agency
Year: 2002
Title: Comparison of multivariate methods
Access Date: August 13, 2002
Abstract: Most of the differences in multivariate methods can be understood in terms of the underlying model which can be defined by the number of independent and dependent variables on each side of the equation and the type of variables included in the model. The tables on this page compare the number and types of variables used in each method.
The tables below use a very simplified form for a multivariate statistical model:
Dependent variable(s) = f(independent variables).
Notes: As of Sept. 6, 2006, web page was no longer available.
URL: http://www.epa.gov/bioindicators/primer/tablemv.html

Reference Type: Journal Article
Author: Ullrich, Walter
Year: 2007
Title: LFT starts Mechtronix level B FFS simulator
Journal: The Journal for Civil Aviation Training (CAT)
Issue: 4
Pages: 33
Date: 2007
ISSN: 0960-9024
Number of Pages: 1
Abstract: The latest investment in simulator technology by Lufthansa Flight Training, a Mechtronix FFS, heralds a move towards innovative, target-oriented business. Walter Ullrich joined invited airlines and training centres to the commissioning ceremony at LFT's Berlin-Schonefeld facility.

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Reference Type: Magazine Article
Author: Ullrich, Walter F.
Year: 2008
Title: A history of simulation: Part II - Early days
Magazine: Military Simulation and Training (MS&T)
Issue Number: 5
Pages: 27-28
Abstract: In this second of a series featuring historic training simulation technology developments Walter F. Ullrich describes early initiatives in flight training and pilot selection.

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Reference Type: Conference Paper
Author: Ungs, Timothy J.
Year: 1987
Title: Simulator induced syndrome: Evidence for long term simulator aftereffects
Conference Name: Human Factors Society 31st Annual Meeting
Conference Location: Santa Monica, CA
Publisher: Human Factors and Ergonomics Society
Author's Title and Affiliation: U.S. Coast Guard and Wright State University
Number of Pages: 5
Abstract: The purpose of this study was to determine the incidence, risk factors, and significance of adverse symptoms occurring in pilots more than 24 hours after completion of flight simulator training. This continued occurrence or recurrence of symptoms is termed by the author as "Long Term Simulator Aftereffects" (LTSA). Information was gathered by a multi-part, anonymous, and voluntary questionnaire. Nine of 196 pilots studied reported LTSA. Several pilots reported symptoms up to one week and one three weeks post simulator training. Symptoms reported included: recurrent visual flashbacks, continued disturbance in balance, difficulties in concentrating and hand-eye coordination. Three pilots reported difficulties in flying aircraft. There was no statistically significant association between LTSA and: total flight time, total simulator time, length of simulator training, self-determined motion sickness susceptibility, and sex. Simulator training can result in the occurrence of long term (1 day) adverse symptoms which poses flight safety concerns.

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Reference Type: Report
Author: University of Toronto
Year: 1991
Title: Annual progress report 1988-1989
City: Downsview, Ontario, Canada
Institution: University of Toronto, Institute for Aerospace Studies

Author's Title and Affiliation: University of Toronto, Institute for Aerospace Studies, 4925 Dufferin Street, Downsview, Ontario, Canada, M3H5T6
Number of Pages: 123
Notes: Presents summaries of work including references, participants, and equipment.

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Reference Type: Thesis
Author: Unnikrishnan, Suraj
Year: 2006
Title: Adaptive envelope protection methods for aircraft
Academic Department: School of Aerospace Engineering
City: Atlanta, GA
University: Georgia Institute of Technology
Degree: PhD
Date: August
Keywords: envelope protection, upset recovery training (URT)
Abstract: Carefree handling refers to the ability of a pilot to operate an aircraft without the need to continuously monitor aircraft operating limits. At the heart of all carefree handling or maneuvering systems, also referred to as envelope protection systems, are algorithms and methods for predicting future limit violations. Recently, envelope protection methods that have gained more acceptance, translate limit proximity information to its equivalent in the control channel.
Envelope protection algorithms either use very small prediction horizon or are static methods with no capability to adapt to changes in system configurations. Adaptive approaches maximizing prediction horizon such as dynamic trim, are only applicable to steady-state-response critical limit parameters. In this thesis, a new adaptive envelope protection method is developed that is applicable to steady-state and transient response critical limit parameters. The approach is based upon devising the most aggressive optimal control profile to the limit boundary and using it to compute control limits. Pilot-in-the-loop evaluations of the proposed approach are conducted at the Georgia Tech Carefree Maneuver lab for transient longitudinal hub moment limit protection.
Carefree maneuvering is the dual of carefree handling in the realm of autonomous Uninhabited Aerial Vehicles (UAVs). Designing a flight control system to fully and effectively utilize the operational flight envelope is very difficult. With the increasing role and demands for extreme maneuverability there is a need for developing envelope protection methods for autonomous UAVs. In this thesis, a full-authority automatic envelope protection method is proposed for limit protection in UAVs. The approach uses adaptive estimate of limit parameter dynamics and finite-time horizon predictions to detect impending limit boundary violations. Limit violations are prevented by treating the limit boundary as an obstacle and by correcting nominal control/command inputs to track a limit parameter safe-response profile near the limit boundary. The method is evaluated using software-in-the-loop and flight evaluations on the Georgia Tech unmanned rotorcraft platform- GTMax. The thesis also develops and evaluates an extension for calculating control margins based on restricting limit parameter response aggressiveness near the limit boundary.
URL: http://smartech.gatech.edu/dspace/handle/1853/11478

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Reference Type: Report
Author: USAF Scientific Advisory Board
Year: 1978
Title: Report of the ad hoc committee on simulation technology
Institution: Department of the Air Force
Date: April

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Reference Type: Journal Article
Author: Vaden, Eric A.; Hall, Steven
Year: 2005
Title: The effect of simulator platform motion on pilot training transfer: A meta-analysis
Journal: International Journal of Aviation Psychology
Volume: 15
Issue: 4
Pages: 375-393
Author's Title and Affiliation: Vaden: Human Factors and Systems Department, Embry-Riddle Aeronautical University
Hall: Galaxy Scientific Corporation, Fairfax, VA
Keywords: meta-analysis, flight simulation, training effectiveness, motion, transfer of training
Abstract: We used a meta-analysis (MA) approach to generate an estimate of true mean effect size (d) for simulator motion with regard to fixed-wing pilot training transfer. We based the analysis on the techniques developed by Hunter and Schmidt (1990). We used a d statistic for effect size calculations based on information available in the included sources. We reviewed and considered 11 studies for analysis, but only 7 of these included the information necessary for calculating effect size and we included these in the study. The result of the MA suggest a small, positive effect for motion, d = .16. No credibility interval could be built around this estimate of population mean effect size because the resulting sampling error variance was larger than the observed variance in d across the assessed studies. This led to a negative variance estimate for d and subsequently an estimated SD_d of 0. These results suggest that simulator motion has a small, positive effect on pilot training transfer and contradict an earlier MA on the same subject. The small sample size (few studies) and methodological shortcomings within the included studies require that the findings be interpreted cautiously. We discuss alternative interpretations and their implications for the aviation training community.
URL: http://www.leaonline.com/doi/pdf/10.1207/s15327108ijap1504_5

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Reference Type: Conference Proceedings
Author: Valente Pais, Ana Rita; van Paassen, M. M.; Mulder, Max; Wentink, Mark
Year of Conference: 2009
Title: Perception coherence zones in flight simulation
Conference Name: AIAA Modeling and Simulation Technologies Conference
Conference Location: Chicago, IL
Publisher: American Institute of Aeronautics and Astronautics (AIAA)
Pages: 1-13
Date: Aug. 10-13
Electronic Resource Number: AIAA-2009-6242
Author's Title and Affiliation: Valente Pais: PhD Student, Faculty of Aerospace Engineering, Control and Simulation Division, Delft University of Technology, Delft, The Netherlands
van Paassen: Associate Professor, Faculty of Aerospace Engineering, Control and Simulation Division, Delft University of Technology, Delft, The Netherlands
Mulder: Professor, Faculty of Aerospace Engineering, Control and Simulation Division, Delft University of Technology, Delft, The Netherlands
Wentink: Researcher, TNO Defense, Security and Safety, Soesterberg, The Netherlands
Number of Pages: 13
Keywords: coherence zones, visual, vestibular, motion cues, motion perception
Abstract: The importance of motion perception knowledge for flight simulation is widely recognized. The development and tuning of motion filters relies on understanding the human motion perception mechanisms and its limitations. Particularly interesting for flight simulation is the study of visual-vestibular coherence zones. Coherence zones refer to combinations of visual and vestibular cues that, although not being a one-to-one match, still provide the pilot with the perception of a congruent motion, indicating a realistic simulation. Coherence zones have been measured before during passive tasks, for pre-determined stimuli. During an active task, however, the type of inertial and visual cues being provided are considerably influenced by the pilot control strategy. For this reason, it is important to understand how the

amplitude and frequency content of the stimuli affect the perception of a coherent motion. Three experiments were performed to measure the effect of the visual cue amplitude and stimuli frequency on yaw perception coherence zones. In accordance with previous research, the measured coherence zones were wider for higher amplitudes of the visual motion cue. In addition to that, for higher amplitudes of the visual cue the point of mean coherence was found to be much lower than the one-to-one line. The stimuli frequency was shown to have an effect on the coherence zones. For a higher frequency stimulus the point of mean coherence was significantly lower than for a lower frequency stimulus. These results were explained using a simple model of the semi-circular canals dynamics.

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Reference Type: Journal Article
Author: Valverde, Horace H.
Year: 1973
Title: A review of flight simulator transfer of training studies
Journal: Human Factors
Volume: 15
Issue: 6
Pages: 510-523
Date: December
Author's Title and Affiliation: Advanced Systems Division, Air Force Human Resources Laboratory, Wright-Patterson Air Force Base, OH
Number of Pages: 14
Keywords: transfer, training, simulator, fidelity, motion
Abstract: Often operational equipment is considered to be the most effective and valid training equipment. However, this is not true in every instance. In fact, sometimes it may be undesirable to use real equipment for training if suitable simulators are available. For example, the use of operational equipment has several disadvantages which include (1) high costs, (2) limitation on practice of varied aspects of tasks, and (3) safety hazards. Practical decisions in the use of training devices depend upon compromises between economic and training objectives. A trainer need not duplicate operational equipment to have training value. Technical reports pertaining to flight simulator transfer of training studies available from the Defense Documentation Center are reviewed.

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Reference Type: Conference Paper
Author: van de Moesdijk, G. A. J.
Year: 1978
Title: Non-gaussian structure of the simulated turbulent environment in piloted flight simulation
Conference Name: Flight Mechanics Panel Specialists' Meeting on Piloted Aircraft Environment Simulation Techniques
Conference Location: Brussels, Belgium
Publisher: Advisory Group for Aerospace Research and Development (AGARD)
Date: April 24-27
Author's Title and Affiliation: Delft University of Technology, Department of Aerospace Engineering, Delft, The Netherlands
Number of Pages: 27
Keywords: non-Gaussian, atmospheric turbulence, simulation, flight tasks, psychological effects
Abstract: After a description of the general non-gaussian characteristics of actual atmospheric turbulence as observed in the atmosphere, a non-gaussian turbulence simulation model has been described. The non-gaussian characteristics have been classified as patchiness and intermittency, both dependent on higher order statistics. These non-gaussian characteristics have been mathematically elaborated and described. The effects of patchiness on pilot's behavior, using physiological parameters have been evaluated in a small simulator experiment.

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Reference Type: Journal Article
Author: van den Berg, A. V.; Van de Grind, W. A.
Year: 1989
Title: Reaction times to motion onset and motion detection thresholds reflect the properties of bilocal motion detectors
Journal: Vision Research
Volume: 29
Issue: 9
Pages: 1261-1266
Number of Pages: 6
Keywords: vision, motion detection threshold, motion detection reaction time
Notes: Referenced in Ruud Hosman's book, Pilot's perception and control of aircraft motions (1996).

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Reference Type: Conference Proceedings
Author: van den Berg, P.; Zaal, P.M.T.; Mulder, M.; Van Paassen, M.M.
Year of Conference: 2007
Title: Conducting multi-modal pilot model identification - Results of a simulator experiment
Conference Name: AIAA Modeling and Simulation Technologies Conference and Exhibit
Conference Location: Hilton Head, SC
Publisher: American Institute of Aeronautics and Astronautics (AIAA)
Date: August 20-23
Electronic Resource Number: AIAA 2007-6892
Author's Title and Affiliation: van den Berg: MSc Student, Control and Simulation Division, Faculty of Aerospace Engineering
Zaal: PhD Candidate, Control and Simulation Division, Faculty of Aerospace Engineering
Mulder: Associate Professor, Control and Simulation Division, Faculty of Aerospace Engineering
van Paassen: Associate Professor, Control and Simulation Division, Faculty of Aerospace Engineering
Delft University of Technology, P.O. Box 5058, 2600 GB Delft, The Netherlands
Abstract: As part of the research project "A cybernetic approach to assess simulator fidelity" an experiment was conducted in the SIMONA Research Simulator. The experiment is performed in preparation of an in-flight experiment with the objective to perform multi-modal pilot model identification during real flight in the Citation II laboratory aircraft of the Delft University of Technology. To capture the pilot's behavior in a mathematical model, the pilot is asked to perform a well defined pitch attitude control task. The multi-modal identification of the pilot requires the pilot to perform a simultaneous target tracking and disturbance rejection task. Two forcing functions are therefore inserted into the closed-loop system. One of the primary goals of the experiment is to gain more insight in the design requirements of the disturbance and tracking signals. The simulator experiment is also used to investigate the effect of turbulence on the accuracy of the identification results. The final goal of the simulator experiment was to investigate the possibility of modifying the aircraft dynamics by using a stick shaping filter. The experiment revealed that the power that can be inserted by the forcing functions is limited by the torque limiters of the autopilot. Turbulence did not affect the identification results significantly. The pilots showed crossover regression for the conditions with the stick-shaping filter. This is probably caused by the high bandwidth of the forcing functions used in combination with double integrator dynamics.

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Reference Type: Book Section
Author: van der Pal, Jelke
Year: 1999
Title: The effect of simulator motion on parameter training for F-16 pilots
Editor: Harris, Don
Book Title: Engineering Psychology and Cognitive Ergonomics: Transportation Systems, Medical Ergonomics and Training

City: Oxford, England
Publisher: Ashgate
Volume: 3
Pages: 267-275
Author's Title and Affiliation: National Aerospace Laboratory (NLR), The Netherlands
Abstract: Although several studies have been reported with respect to the training value of platform motion systems for military training, most of them are now outdated due to technological improvements and improved measurement techniques. Within the experiment reported here, a quasi transfer-of-training design has been applied, using a modern 6-DOF, dome simulator for the F-16 as a training device to train experienced pilots on flight parameters for a weapon delivery maneuver. The pilots obtained good learning progress. However, despite expectations, pilots training with motion cueing tended to perform worse than pilots trained without motion cueing. Motion cueing did not lead to faster learning. On transfer, the lack of motion during training did not lead to a consistent negative effect. However, without motion cueing, pilots' learned control strategies were less efficient during transfer, as more input corrections were needed.

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Reference Type: Journal Article
Author: van der Steen, F. A. M.
Year: 1996
Title: Simulating self-motion
Journal: Brain Research Bulletin
Volume: 40
Pages: 473-475
Author's Title and Affiliation: Delft University of Technology, Faculty of Aerospace Engineering, Kluyverweg 1, 2629 HS Delft, The Netherlands, Email: Han.Steen@LR.TUDelft.NL
Number of Pages: 3
Keywords: virtual environments, vehicle simulation, self-motion perception, visual-vestibular, interaction, perception model
Abstract: In general, vehicle motions far exceed the mechanical constraints of an Earth-fixed simulator base. Inertial motions can therefore only be simulated in partial agreement with those of the actual vehicle. As a consequence, physical mismatches between inertial and environmental motion are inevitable. Here, the concept of a subjective reference frame is introduced, relative to which perceived self-motion is defined. This frame must be released from the Earth-fixed frame in order to evoke simulated self-motion. In addition, self-motion and environmental motion need to be perceived reciprocal, in order to evoke a stationary perceived environment. Due to the only limited accuracy of human self-motion perception, however, perceived self-motion and perceived environmental motion need not be *exactly* reciprocal. The extent to which self-motion and environmental motion may differ, can be expressed by a just noticeable difference. This just noticeable difference denotes the threshold at which the environment is perceived to move. In this paper, a self-motion perception model is outlined in which perceived environmental motion and perceived self-motion are separated. The perception model and the just noticeable differences can then be applied to determine the inertial stimulation that is needed to evoke perceived self-motion, in which the environment is perceived stationary throughout simulation.

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Reference Type: Report
Author: van der Steen, F. A. M.
Year: 1996
Title: A stationary perceived visual scene during roll and yaw motions in a flight simulator
Author's Title and Affiliation: Delft University of Technology, Faculty of Aerospace Engineering, Delft, The Netherlands
Number of Pages: 36
Keywords: self-motion, perception, visual-vestibular, simulator

Abstract: In two experiments, human observers in a moving base flight simulator were subjected to angular accelerations. The first experiment concerned accelerations about the longitudinal roll axis. The second experiment concerned accelerations about the vertical yaw axis. It was determined to which extent the amplitudes of inertial body motion (with respect to an earth-fixed frame) and visual scene motion (with respect to the simulator cabin) may differ, while maintaining the perception of an earth-stationary visual scene. Both the body and visual motion consisted of a 0.75 *s* acceleration, followed by a 1.50 *s* deceleration, and a 0.75 *s* acceleration. The visual acceleration amplitude *W* was fixed at either 0, 2, 4, 8, or 12 deg/s^2 while the inertial acceleration amplitude *I* was varied by a staircase procedure, depending on whether the subject had perceived the scene to be stationary or not. Following the visual and inertial motion presentation, the subjects pushed a button when they perceived the scene to be not stationary. At each displayed visual motion amplitude, the "slow" and "fast" inertial threshold amplitudes were determined in between which the visual scene was perceived to be stationary. At the slow threshold, the inertial amplitude is too small while at the fast threshold, this amplitude is too large to evoke the perception or an earth-stationary visual scene. The slow thresholds were determined for $W = 0$ through $W = 12$ deg/s^2 and satisfy the linear relation $I = 2.7 + 1.7\ W$ for roll and $I = 2.2 + 1.4\ W$ for yaw. When considering the slow and fast threshold amplitudes to have symmetry at the $W = 0$ condition, a strong non-linearity of the thresholds near $W = 0$ was found.

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Reference Type: Thesis
Author: van der Steen, Han
Year: 1998
Title: Self-motion perception
City: Delft, The Netherlands
University: Delft University of Technology
Thesis Type: Ph.D.
Keywords: perception of self-motion

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Reference Type: Conference Paper
Author: van der Steen, Han
Year: 2000
Title: Measuring the realism of motion in flight simulators
Conference Name: AIAA Modeling and Simulation Technologies Conference
Conference Location: Denver, CO
Publisher: American Institute of Aeronautics and Astronautics (AIAA)
Date: August 14-17
Electronic Resource Number: AIAA-2000-4293
Author's Title and Affiliation: Siemens - Traffic, Transport and Special Projects division
Number of Pages: 6

Abstract: A prominent issue in flight simulation technology is the extent to which inertial (mechanical) motions are necessary. A condition that refers to the need for inertial motions is the perceptual condition that the simulator trainee may not perceive self-movements as unrealistic.
This paper describes results of experiments in a flight simulator which determined inertial motion amplitudes which are needed to provide realistic motion. Two motion directions were tested: roll and yaw. The experiments demonstrated that the perception of an earth-stationary visual scene corresponds to the perception of realistic self-motion. It is outlined that rather large ranges exist in which visual and inertial self-motion stimuli may physically mismatch, while the simulated self-motion is perceived as realistic.

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Reference Type: Conference Paper
Author: van der Steen, Han F. A. M.; Hosman, Ruud J. A. W.
Year: 1995
Title: Perception of coherence of visual and vestibular velocity during rotational motion
Conference Name: IFAC Symposium on Analysis, Design and Evaluation of Man-Machine Systems
Conference Location: Massachusetts Institute of Technology, Cambridge, MA
Author's Title and Affiliation: Delft University of Technology, Faculty of Aerospace Engineering, P.O. Box 5058, 2600 GB, Delft, The Netherlands
Number of Pages: 6
Keywords: human perception, visual motion, thresholds, many-degrees-of-freedom systems, simulators
Abstract: Psychophysical experiments are described that concern the ability of subjects to indicate the velocity coherence of vestibular and visual stimuli during rotations. The coherence zone is determined by the thresholds at which the suggested outside visual world is no longer perceived as stationary. The results show high gains for roll and swing (1 to 6) and gains about one (0.5 to 2) for yaw motions. The use of perceived coherence zones in moving-base vehicle simulation is discussed.

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Reference Type: Report
Author: van der Vaart, J. C.; Hosman, R. J. A. W.
Year: 1987
Title: Compensatory tracking in disturbance tasks and target following tasks. The influence of cockpit motion on performance and control behavior
City: Delft, The Netherlands
Institution: Delft University of Technology
Date: December
Report Number: Report LR-51 l
Number of Pages: 53

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Reference Type: Conference Paper
Author: van Gool, M. F. C.
Year: 1978
Title: Influence of motion washout filters on pilot tracking performance
Conference Name: Flight Mechanics Panel Specialists' Meeting on Piloted Aircraft Environment Simulation Techniques
Conference Location: Brussels, Belgium
Publisher: Advisory Group for Aerospace Research and Development (AGARD)
Date: April 24-27
Author's Title and Affiliation: National Aerospace Laboratory NLR, Anthony Fokkerweg 2, 1059 CM Amsterdam, The Netherlands
Number of Pages: 5
Keywords: motion washout filters, human motion perception, tracking
Abstract: An investigation has been carried out on the NLR moving base flight simulator to establish the influence of the simulator motion wash-out filters in the pitch and roll axis in the performance of four pilots when stabilizing an aircraft disturbed by turbulence in one of these axes. For this compensatory tracking task, pilot describing functions, remnant spectra and other performance measures have been determined. The results lead to the conclusion that, for the task under consideration, no significant differences can be observed when the break frequency of the (linear second-order) wash-out filter is varied from 0.1 rad/sec to 0.5 rad/sec. However performance in either condition is considerably better when compared to fixed-rate results. This is also reflected in the pilot comments and effort ratings, stating that the task is easier with motion.

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Reference Type: Conference Paper
Author: van Leeuwen Bookamp, Pieter-Jan
Year: 2003
Title: A strategic view on ATC training
Conference Name: Simulation of the Environment
Conference Location: London, UK
Publisher: Royal Aeronautical Society (RAeS)
Number of Pages: 6
Abstract: The paper handles the current ATC Training situation in The Netherlands, focussing on the use of ATC Simulators.
The simulators that are now being used in the ATC Training by the Dutch are mentioned for the Initial, Advanced and Recurrent Training.
ATC Training is moreover a person-to-person situation, taking considerable time, considerable effort and the technical state of simulation is still in the stone-ages period. As an example to run one exercise for two ATC candidates sometimes five pseudo-pilots are necessary.
Besides that the rate of success in ATC Training is seldom higher than 50%. Nevertheless in Europe alone there are still over a 10.000 ATCOs successful to be trained to accommodate the required manpower of ATC Providers till 2008.
The big challenge for the industry is to find the balance in this market between the tailor made requirements and standard-products.
Mr. Van Leeuwen Bommkamp suggests a pro-active role of the industry to search for the customer requirements. More than 'this is on the shelf, use this for that'. Didactical aspects, cost saving aspects, increasing the rate of success, reducing the use of Psuedo Pilots, reducing the number of ATC Instructors are topics that the current managers of ATC Providers nowadays are being challenged.

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Reference Type: Conference Paper
Author: Veltink, Peter H.; Luinge, Henk J.; Kooi, Bart J.; Baten, Chris T.M.; Slycke, Per; Olthuis, Wouter; Bergveld, Piet
Year: 2002
Title: The artificial vestibular system: Design of a tri-axial inertial sensor system and its application in the study of human involvement
Conference Name: Measuring Behavior, 4th International Conference on Methods and Techniques in Behavioral Research
Conference Location: Amsterdam, The Netherlands
Publisher: Noldus Information Technology bv
Date: August 27-30
Author's Title and Affiliation: Veltink and Luinge: Institute for Biomedical Technology (BMTI)
Kooi, Olthuis, Bergveld: MESA Institute, University of Twente, P.O. Box 217, 7500 AE Enschede, the Netherlands
Baten, Slycke, Wouter: Xsens Sports Technologies bv, P.O. Box 545, 7500 AM Enschede, the Netherlands

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Reference Type: Journal Article
Author: Veltman, J. A.
Year: 2002
Title: A comparative study of psychophysiological reactions during simulator and real flight
Journal: International Journal of Aviation Psychology (IJAP)
Volume: 12
Issue: 1
Pages: 33-48
Author's Title and Affiliation: TNO Human Factors, Soesterberg, The Netherlands
Number of Pages: 16

Abstract: During selection tests in a flight simulator and a real aircraft, physiological workload measures were evaluated. The selection context guaranteed high motivation in the participant to exert additional effort during difficult flight tasks. The aim of the study was to obtain information about the sensitivity to mental effort of several physiological measures and to explore the applicability of these measures in real flight. The following measures were used: heart rate, heart rate variability, respiration (frequency and amplitude), blood pressure, eye blinks (frequency, duration and amplitude), and saliva cortisol. Blood pressure was the only measure that was difficult to obtain during real flights.
All physiological measures showed large differences between baseline and flight tasks. Heart rate, heart rate variability, and respiratory frequency showed similar results in the simulator and real flight. Blink frequency showed an expected decrease during simulator flight, whereas a large increase was found during real flight. This can be partly explained by eye movements, which were made more frequently during real flight. Blink duration was shorter and amplitude was larger during both flights. This indicates that a combination of blink parameters provides better information about workload than blink frequency alone. Cortisol was not affected by the simulator flight, whereas greatly increased levels were found after the real flight. This indicates that cortisol is not affected by mental effort. G-forces during the real flight most likely caused the increased cortisol levels.

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Reference Type: Conference Proceedings
Author: Vice, Jack M.; Lathan, Corinna; Lockerd, Anna D.; Hitt, James M. II
Year of Conference: 2007
Title: Simulation fidelity design informed by physiologically-based measurement tools
Editor: Schmorrow, Dylan D.; Reeves, Leah M.
Conference Name: Foundations of Augmented Cognition
Conference Location: Beijing, China
Publisher: Springer
Pages: 186-194
Series Editor: Carbonell, Jaime G.; Siekmann, Jorg
Date: 2007
Number of Pages: 9
Keywords: virtual reality, simulation, transfer of training, physiology, behavior, training effectiveness
Abstract: Virtual environments (VE's) and simulations are being employed for training applications in a wide variety of disciplines, both military and civilian. The common assumption is that the more realistic the VE, the better the transfer of training to real world tasks. However, some aspects of task content and fidelity may result in stronger transfer of training than even the most high fidelity simulations. A physiologically-based system capable of dynamically detecting changes in operator behavior and physiology throughout a VE experience and comparing those changes to operator behavior and physiology in real-world tasks, could potentially determine which aspects of VE fidelity will have the highest impact on transfer of training. Thus, development of training assessment and guidance tools that utilize operator behavior and physiology to determine VE effectiveness and transfer of training are needed.

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Reference Type: Journal Article
Author: Vinje, Edward W.; Pitkin, Edward T.
Year: 1972
Title: Human operator dynamics for aural compensatory tracking
Journal: IEEE Transactions on Systems, Man, and Cybernetics
Volume: SMC-2
Issue: No. 4
Pages: 504-512
Keywords: human operator dynamics, compensatory tracking, aural display
Abstract: The effects of aural and combined aural and visual displays of tracking error on human operator dynamics were investigated using a compensatory tracking task. The aural displays indicated

error magnitude with tone pitch and error polarity by either modulating the tone or by switching it between the ears. Describing functions, remnants, and rms tracking performance were measured with test conditions which were similar to those for previous studies of visual tracking performance. Human operator control characteristics measured for aural displays agree closely with those which result for visual displays. Also, operators could control equally well with either one- or two-ear displays. However, the reduction in operator time delays, expected because of the generally faster human response to aural stimuli, was not clearly evident in the results. Results also indicate that the combined aural and visual presentation of tracking error improved operator performance slightly.

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Reference Type: Journal Article
Author: Vogel, Ben
Year: 2010
Title: Driving down runway incursions
Journal: Jane's Airport Review
Pages: 22-25
Date: July/August 2010
Number of Pages: 4

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Reference Type: Conference Paper
Author: Vogl, E.
Year: 1978
Title: Differences between simulation and real world at the IABG Air to Air Combat Simulator with a wide angle visual system
Conference Name: Flight Mechanics Panel Specialists' Meeting on Piloted Aircraft Environment Simulation Techniques
Conference Location: Brussels, Belgium
Publisher: Advisory Group for Aerospace Research and Development (AGARD)
Date: April 24-27
Author's Title and Affiliation: Industrieanlagen-Betriebsgesellschaft, 8012 Ottobrunn, FRG
Number of Pages: 11
Keywords: wide angle visual system, air to air combat
Abstract: This paper presents the experiences of IABG with its Dual Flight Simulator (DFS) for air-to-air combat. First of all IABG has discovered that air-to-air combat simulation without a motion system is no problem to its pilots. During the verification phase it was found that the results of simulators at DFS were very good.
On the other hand IABG has researched all simulator effects in respect to human factors. All of the following effects are existent, but have an unimportant influence on the results of air-to-air combat simulations.

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Reference Type: Magazine Article
Author: von Croy, Alexis
Year: 2007
Title: Perfect go-around
Magazine: Planet AeroSpace
Issue Number: 1
Pages: 4-11
Date: January
Number of Pages: 7
Keywords: ATR 42-500, ATR 72-500, turboprop
Abstract: Threatened with extinction by the global turboprop crisis only a few years ago, ATR - the European joint venture between EADS and Alenia Aeronautica, part of the Italian Finmeccanica group - is

now the world's leading manufacturer of turboprop regional airliners. Planet AeroSpace went to visit the company in Toulouse.

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Reference Type: Report
Author: von der Heyde, Markus; Riecke, Bernhard E.
Year: 2001
Title: How to cheat in motion simulation - Comparing the engineering and fun ride approach to motion cueing
Pages: 1-8
Date: December
Type: Technical Report
Report Number: TR No. 089
Number of Pages: 9
Abstract: The goal of this working paper is to discuss different motion cueing approaches. They stem either from the engineering field of building flight and driving simulators, or from the modern Virtual Reality fun rides presented in amusement parks all over the world. The principles of motion simulation are summarized together with the technical implementations of vestibular stimulation with limited degrees of freedom. A psychophysical experiment in Virtual Reality is proposed to compare different motion simulation approaches and quantify the results using high-level psychophysical methods as well as traditional evaluation methods.

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Reference Type: Magazine Article
Author: Voorhees, James W.; Waddington, Michael J.
Year: 1994
Title: Fidelity in human-in-the-loop driving simulation
Magazine: Traffic Technology International
Issue Number: Winter
Pages: 76-77, 79-80
Author's Title and Affiliation: In-Mar-Tech, Australia
Number of Pages: 4
Keywords: physical fidelity, system fidelity, environmental fidelity, situational fidelity, Real Drive simulator
Abstract: This article examines the technologies for designing successful vehicle simulators, and describes the Real Drive simulator commissioned by the Victorian Transport Accident Commission (TAC) in Australia. 'Fidelity' is the degree of correspondence between a simulated system and the real world system that it represents. It has several forms (physical, system, environmental, and situational) and many different levels. It is important in simulation, because training, assessment and research all aim to improve performance in the real world. Cost and design flexibility are also important. The Victorian TAC and the Monash University Accident Research Centre (MUARC) decided to investigate the young driver problem by using driving simulators as a training device and research tool. After their worldwide survey found no suitable existing simulators, the Real Drive simulator project was launched. Situational and physical fidelity were found to be essentially important, and system and environmental fidelity to relate to research and training needs. The Real Drive simulator toured the USA during Summer 1994. Over 1000 people had an opportunity to drive it and record their opinions about its four types of fidelity. The article reports some of these comments.

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Reference Type: Report
Author: Waag, Wayne L.
Year: 1981
Title: Training effectiveness of visual and motion simulation
City: Williams Air Force Base, AZ
Institution: Air Force Human Resources Laboratory
Date: January
Type: Interim Report
Report Number: AFHRL-TR-79-72
Author's Title and Affiliation: Operations Training Division, Air Force Human Resources Laboratory, Williams Air Force Base, AZ 85221
Number of Pages: 27
Keywords: visual simulation, motion simulation, flight simulation, transfer of training, flight training
Abstract: A review of the literature concerning the training effectiveness of visual and motion simulation is presented in this report. Although there exist much pilot opinion and in-simulator performance data, their extrapolation to training effectiveness information is questioned. The present review focuses on data obtained through the application of the transfer-of-training methodology. The results are discussed in terms of study design factors, and recommendations are made wherein additional research data are needed.

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Reference Type: Report
Author: Wade, Michael G.; Hammond, Curtis
Year: 1998
Title: Simulation validation: Evaluating driver performance in simulation and the real world
Date: July
Type: Technical Report
Report Number: MN/RC - 1998-28
Author's Title and Affiliation: University of Minnesota, Human Factors Research Laboratory, 1901 4th Street, S.E., Minneapolis, MN 55455
Number of Pages: 101
Keywords: simulation performance, collision avoidance, driver behavior
Abstract: Simulation offers a cost-effective way to conduct research on collision avoidance and accident prevention. To be effective, simulated performance must be a valid measure of real world performance. This project sought to validate real world driving performance based on the performance of individuals driving in simulation.
The study presents performance data on 14 male and 12 female volunteer subjects who drove a route adjacent to the University of Minnesota campus and then performed in a similar computer-generated driving route. Generally, subjects reported the simulated driving test comfortable and realistic; performance and characteristics of driving in the simulator closely paralleled the real world; the qualitative pattern of driving was similar; and errors and the control parameters of driving performance suggested acceptable reliability between both driving worlds. Researchers concluded that the simulator performed reliably and provided a valid set of performance data that could be used to better understand driving behavior, especially as it related to accident prevention and collision avoidance.

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Reference Type: Magazine Article
Author: Wainwright, William
Year: 1999
Title: Airplane upset recovery: A test pilot's point of view
Magazine: FAST
Issue Number: 24
Pages: 18-23
Date: January 6

Author's Title and Affiliation: Captain; Chief Test Pilot, Airbus Industrie
Keywords: upset recovery training (URT), Upset Recovery Training Aid
Abstract: The idea for a joint industry working group to produce an Airplane Upset Recovery Training Aid was first proposed by ATA in June 1996. It was in response to increasing interest by the NTSB in aircraft loss of control accidents which, together with Controlled Flight into Terrain, cause a large proportion of all accidents. They were putting a lot of pressure on the FAA to produce new regulations covering this subject.
The working group was a voluntary initiative to see what could be done within the existing regulations to improve the situation.
The joint industry team consisted of representatives of all sides of industry: aircraft manufacturers, airlines, governmental authorities, and pilots' unions. It was a good example of how the entire industry, designers, users, and regulators can co-operate on safety issues that are common to everyone. It also marked a "first" in showing that the "Big 3" aircraft manufacturers could and will work together on technical, non-commercial issues. More than 80 persons coming from around the world, but principally from the USA, participated from time to time.
The end result of two years work is a training package including a video and a CD-ROM, giving an airplane upset recovery training aid. This package is on free issue to all our customers, to use as they wish. However, all members of the joint industry group agreed that the package is aimed at preventing loss of control accidents on conventional aircraft. It is not aimed at Fly-by-Wire aircraft.
There is no need for this type of continuation training on protected aircraft, although a general knowledge of the principles involved is useful for every pilot.
The content of the package is not the subject of this article, but there are a few issues of general interest which I gained from my experience as a member of the working group which I would like to mention.
URL: http://www.britflight.com/wingfiles/flight/upsetrecovery.pdf

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Reference Type: Electronic Article
Author: Wald, Matthew L.
Year: 1994
Title: Commuter airlines need tougher rules, panel says
Periodical Title: New York Times
Keywords: Commuter Rule, One Level of Safety
Abstract: [First two paragraphs] The National Transportation Safety Board said today that commuter airline pilots fly more hours than major-carrier pilots but receive less training, less help on safety issues, less help from ground personnel and less rest between flights.
The board said there was no justification for the differences and called on the Federal Aviation Administration to put most commuter operations under the same rules the big airlines must follow.
Notes: Date of article is November 16, 1994
URL:
http://query.nytimes.com/gst/fullpage.html?res=9E0CE5D71531F935A25752C1A962958260&sec=&spon=&pagewanted=all
Access Date: June 6, 2008

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Reference Type: Magazine Article
Author: Walker, K.
Year: 2005
Title: Plugging in
Magazine: Training & Aviation Journal
Pages: 40
Date: October
Number of Pages: 1
Abstract: Latest full-flight simulators feature electric motion systems.

Reference Type: Electronic Article
Author: Wallace, James
Year: 2000
Title: 2 loud bangs preceded fall of flight 261
Periodical Title: Seattle Post-Intelligencer
Issue: February 5
Keywords: Alaska Airlines flight 261, compressor stall, upset recovery training (URT)
Abstract: Voice recorders picked up sounds as pilots struggled to control plane.
URL: http://seattlepi.nwsource.com/local/crsh05.shtml
Access Date: October 19, 2006

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Reference Type: Newspaper Article
Reporter: Wallace, James
Year: 2000
Title: Unlike Airbus, Boeing lets aviator override fly-by-wire technology
Newspaper: Seattle Post-Intelligencer
City: Seattle, WA
Issue Date: March 20
Keywords: fly-by-wire (FBW), envelope protection, upset recovery training (URT)
URL: http://seattlepi.nwsource.com/business/boe202.shtml

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Reference Type: Report
Author: Wargo, M. J.; Kelley, C. R.; Mitchell, M. B.; Prosin, D. J.
Year: 1967
Title: Human operator response speed, frequency, and flexibility: A review, analysis and device demonstration
City: Santa Monica, CA
Institution: Dunlap and Associates, Inc.
Pages: 1-74
Date: November
Report Number: NASA CR-874
Author's Title and Affiliation: Dunlap and Associates, Inc., Santa Monica, CA
Recipient's Title and Affiliation: Electronics Research Center, National Aeronautics and Space Administration (NASA)
Number of Pages: 75
Abstract: (taken from Summary) The human operator's manual control speed, frequency and flexibility is limited by his innate characteristics and by the state-of-the-art in manual control technology. The basis of these limitations was reviewed and analyzed and recommendations for overcoming or reducing these limitations were suggested. On the basis of these suggestions a muscle action potential control, simultaneous visual-auditory display device was developed to demonstrate the increase in operator response speed, frequency and flexibility that accrue from advanced manual control techniques.
In a discrete control situation muscle action potential control was found to increase response speed by approximately 100 ms and simultaneous visual-auditory display was found to reduce response time by an additional 40 ms. In a continuous control situation, muscle action potential control via the facial muscles increased operator response bandwidth across a range of forcing function amplitudes. These results demonstrate the increase in response speed, frequency and flexibility that accrues from use of muscle action potential control and suggests that further development of muscle action potential control devices is warranted.

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Reference Type: Magazine Article
Author: Warwick, Graham
Year: 1996
Title: SIMONA seeks realism
Magazine: Flight International
Pages: 57
Date: April 17-23
Number of Pages: 1

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Reference Type: Magazine Article
Author: Warwick, Graham
Year: 2006
Title: Lufthansa low-cost order will test industry opinion
Magazine: Flight International
Date: April 18
Keywords: Level B, flight training device (FTD), Mechtronix
Abstract: Decision to buy low-fidelity Level B machine could have far-reaching impact.
URL: http://www.mechtronix.com/c/mech/file_db/MC_Pdf_e/flight_international_april_20061.pdf

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Reference Type: Conference Proceedings
Author: Wasei, A.M.; Stroosma, O.; Damveld, H.J.; Mulder, M.; Van Paassen, M.M.
Year of Conference: 2008
Title: Investigating the role of simulator motion cues during simulation of in-flight PIOs
Conference Name: AIAA Modeling and Simulation Technologies Conference
Conference Location: Honolulu, HI
Publisher: American Institute of Aeronautics and Astronautics (AIAA)
Date: August 18-21
Electronic Resource Number: AIAA 2008-6538
Author's Title and Affiliation: Delf University of Technology, Delft, The Netherlands
Abstract: When simulating in-flight PIOs the researcher is faced with the question whether the inclusion of the motion capabilities of ground simulators have an added value to the results. If so, what kind of motion will best provide the adequate cues to the pilot in the simulator? This paper describes an experiment on moving-base hexapod SIMONA Research Simulator (SRS) that reproduced parts of an actual flight campaign conducted by the German Aerospace Center (DLR). During the real flight campaign measurement of the aircraft state and pilot subjective ratings were gathered. Based on this set of data, an experiment on the SRS was set up to investigate the role of different simulator configurations on pilot behavior and performance and compare the pilot ratings with those from the flight campaign. The experiment was conducted with the two pilots that flew the original flight campaign. Three motion conditions were defined: roll, sway and no motion. For each condition the outside visual scene was either turned on or off. Subjective pilot ratings were measured. There are differing results per pilot. Subjective ratings of pilot 1 show large variation and no real differences between the simulator configurations, while those of pilot 2 show a general trend. For pilot 2 the roll motion came closest to matching the in-flight ratings and no-motion case was consistently rated better in the simulator than in flight. Sway motion condition resulted in ratings somewhere in between.
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M.Mulder@TUDelft.NL
M.M.VanPaassen@TUDelft.NL

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Reference Type: Magazine Article
Author: Weible, Jack
Year: 2007
Title: Raptor's solo challenge
Magazine: Training & Simulation Journal (TSJ)
Volume: 9
Issue Number: 1
Pages: 18-20
Date: February/March
Abstract: Fledgling fighter pilots have traditionally spent time in a two-seat version of the jets they will fly, where they are accompanied by an experienced flight instructor. A new group of trainees learning to fly the single-seat-only F-22 won't have that luxury. Jack Weible explains how an intensive mix of time in classrooms and simulators prepares U.S. airmen to fly the Raptor solo.

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Reference Type: Journal Article
Author: Weingarten, Norman C.
Year: 2003
Title: History of in-flight simulation & flying qualities research at Calspan
Journal: Journal of Aircraft
Volume: 42
Issue: 2
Date: March/April
Alternate Journal: AIAA Atmospheric Flight Mechanics Conference, August 2003, Austin, TX AIAA Paper 2003-5464
Author's Title and Affiliation: Calspan Corporation, Flight Research, Buffalo, NY 14225
Number of Pages: 15
Keywords: in-flight simulation, Calspan, variable stability aircraft
Abstract: Calspan Corporation has been the primary innovator, developer, and operator of in-flight simulators in the United States as well as the rest of the world since 1947. Though other agencies and countries have developed their own in-flight simulators, this paper concentrates on Calspan accomplishments in this field. In-flight simulation puts the pilot in the real flight environment and has been used in the development of new aircraft, research of flying qualities and flight control systems, and training of pilots and engineers in these areas. More recent uses have been in the field of display systems and as avionics test beds. This paper starts with the early technologies that led to the development of variable stability aircraft and their earlier applications. It then describes Calspan's history in the development and utilization of in-flight simulation, starting in 1949 with the first flight of the F4U-5 and its auxiliary rudder surface up to the present with the five degree-of-freedom F-16 Variable Stability In-Flight Simulator and Test Aircraft (VISTA). Specific case studies are presented which describe the development and distinctive features of the Calspan in-flight simulators and highlight some of the more significant applications of these unique tools.
URL: http://www.calspan.com/pdfs/IFS_History_AIAA%20Paper_Calspan.pdf

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Reference Type: Conference Paper
Author: Weingarten, N. C.
Year: 2003
Title: History of in-flight simulation & flying qualities research at General Dynamics
Conference Name: AIAA Atmospheric Flight Mechanics Conference
Conference Location: Austin, TX
Publisher: American Institute of Aeronautics and Astronautics (AIAA)
Date: August
Author's Title and Affiliation: General Dynamics Advanced Information Systems, Flight and Aerospace Research, Buffalo, NY 14225

Number of Pages: 16
Keywords: in-flight simulation, upset recovery training (URT), variable stability airplane
Abstract: General Dynamics–Advanced Information Systems (GDAIS) (formerly Veridian) has been the primary innovator, developer, and operator of in-flight simulators in the United States, as well as the rest of the world, since 1947. Though other agencies and countries have developed their own in-flight simulators, the focus is on GDAIS accomplishments in this field. In-flight simulation puts the pilot in the real flight environment and has been used in the development of new aircraft, research of flying qualities and flight-control systems, and training of pilots and engineers in these areas. More recent uses have been in the field of display systems and as avionics test beds. Early technologies that led to the development of variable stability aircraft and their earlier applications, are described first, followed by GDAIS's history in the development and utilization of in-flight simulation, starting in 1949 with the first flight of the F4U-5 and its auxiliary rudder surface, up to the present with the five-degree-of-freedom F-16 Variable Stability In-Flight Simulator and Test Aircraft. Specific case studies are presented that describe the development and distinctive features of each of the GDAIS in-flight simulators and some of the more significant applications of these unique tools are highlighted.

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Reference Type: Electronic Article
Author: Weiss, Yair; Simoncelli, Eero P.; Adelson, Edward H.
Year: 2002
Title: Motion illusions as optimal percepts
Periodical Title: Nature Neuroscience
Volume: 5
Issue: 6
Pages: 598-604
Author's Title and Affiliation: Weiss: School of Computer Engineering, Hebrew University of Jerusalem, Givat Ram Campus, Jerusalem 91904, Israel
Simoncelli: Howard Hughes Medical Institute, Center for Neural Science and Courant Institute of Mathematical Sciences, New York University, 4 Washington Place, New York, NY 10003, USA
Adelson: Brain and Cognitive Sciences Department, Massachusetts Institute of Technology, 77 Massachusetts Avenue, Cambridge, MA 02139, USA
Keywords: visual motion perception, local image velocity, visual illusions
Abstract: The pattern of local image velocities on the retina encodes important environmental information. Although humans are generally able to extract this information, they can easily be deceived into seeing incorrect velocities. We show that these 'illusions' arise naturally in a system that attempts to estimate local image velocity. We formulated a model of visual motion perception using standard estimation theory, under the assumptions that (i) there is noise in the initial measurements and (ii) slower motions are more likely to occur than faster ones. We found that specific instantiation of such a velocity estimator can account for a wide variety of psychophysical phenomena.
URL: http://www.nature.com/neuro/journal/v5/n6/pdf/nn858.pdf
http://web.mit.edu/persci/people/adelson/pub_pdfs/weiss_bayes_nn_02.pdf
Author Address: yweiss@cs.huji.ac.il
Access Date: August 15, 2007

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Reference Type: Journal Article
Author: Weizmann, Michael; Cobb, Peter
Year: 2007
Title: CAE True Environment air traffic control
Journal: CAE's Civil Simuation & Training News
Issue: 16
Pages: 6
Number of Pages: 1

Abstract: Expert studies have shown that improved realism in the simulated aircraft communications environment could enhance safety by improving flight crew training as well as increasing instructor/evaluator effectiveness. As a result flight simulators would benefit from automated air traffic control (ATC) environment simulation to make the training experience more representative of the real world environment improving the training and evaluation of students.

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Reference Type: Conference Paper
Author: Welch, Brian L.
Year: 1978
Title: Recent advances in television visual systems
Conference Name: Flight Mechanics Panel Specialists' Meeting on Piloted Aircraft Environment Simulation Techniques
Conference Location: Brussels, Belgium
Publisher: Advisory Group for Aerospace Research and Development (AGARD)
Date: April 24-27
Author's Title and Affiliation: CAE Electronics Ltd., P.O. Box 1800, St. Laurent, Montreal, Quebec H4L 4X4 Canada
Number of Pages: 12
Keywords: television visual systems, display system
Abstract: A closed circuit television (CCTV) model board visual system, which was designed for a CH-47 helicopter, is described herein. The attributes and deficiencies of the system are discussed in an attempt to show how a model board based visual system suitable for full mission simulation in Nap of the Earth (NOE) environments could be designed. A new computer generated image (CGI) visual system which makes extensive use of texture is presented as an alternative to the model board approach. The importance of realism in full mission simulators as distinct from flight and weapons trainers is also discussed.

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Reference Type: Conference Proceedings
Author: Wentink, Mark; Correia Grácio, Bruno; Bles, Wim
Year of Conference: 2009
Title: Frequency dependence of allowable differences in visual and vestibular motion cues in a simulator
Conference Name: AIAA Modeling and Simulation Technologies Conference
Conference Location: Chicago, IL
Publisher: American Institute of Aeronautics and Astronautics (AIAA)
Pages: 1-11
Date: Aug. 10-13
Electronic Resource Number: AIAA-2009-6248
Author's Title and Affiliation: Wentink: Technical Manager, Desdemona Simulator, Perception & Simulation, TNO Human Factors, Soesterberg, The Netherlands
Correia Grácio: PhD Student, Perception & Simulation, TNO Human Factors, Soesterberg, The Netherlands
Bles: Senior Research Scientist, Perception & Simulation, TNO Human Factors, Soesterberg, The Netherlands
Number of Pages: 11
Keywords: visual-vestibular coherence zone, visual, intertial, simulator motion, motion perception
Abstract: In the real world in which we move around, inertial and visual motion are usually equal; what you see is what you feel. In a simulator, however, this is usually not the case. On the contrary, due to the relatively small motion space of even the largest simulators, the inertial motion cues must be filtered and scaled down considerably. Typically, inertial motion cues are high-pass filtered and scaled down by as much as fifty to seventy percent in a flight simulator. This does not necessarily mean that the motion simulation is unnatural or unconvincing, since certain differences between inertial and visual motion cannot be detected by the human perceptual system. Especially, when the visual scene has rich content

with a lot of detail, high-contrast and a wide field-of-view. The maximum allowable difference between visual and inertial motion that goes undetected is defined as the visual-vestibular coherence zone. Knowledge of these coherence zones is very valuable for the development of effective simulator motion cueing. The results of the yaw motion perception experiment described in this paper provide strong indications that the coherence zone between visual and inertial yaw motion is not simply determined by a simple gain or threshold, but is frequency dependent. From a perception modeling point-of-view one can argue that the frequency dependency is related to the inverse dynamics of the semicircular canals. The experimental findings support this argument, although further research is required to determine a more precise dynamic coherence zone and to test other degrees-of-freedom.

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Reference Type: Journal Article
Author: Wertheim, Alexander H.
Year: 1994
Title: Motion perception during self-motion: The direct versus inferential controversy revisited
Journal: Behavioral and Brain Sciences
Volume: 17
Issue: 2
Pages: 293-355
Type of Article: Draft
Author's Title and Affiliation: TNO Institute for Perception, P.O. Box 23, 3769 ZG, Soesterberg, The Netherlands
Keywords: motion perception, velocity perception, self-motion, extraretinal signal, efference copy, direct perception, visual-vestibular interactions
Abstract: According to the traditional inferential theory of perception, percepts of object motion or stationarity stem from an evaluation of afferent retinal signals (which encode image motion) with the help of extraretinal signals (which encode eye movements). Direct perception theory, on the other hand, assumes that the percepts derive from retinally conveyed information only. Neither view is compatible with a special perceptual phenomenon which occurs during visually induced sensations of ego-motion (vection). A modified version of inferential theory yields a model in which the concept of an extraretinal signal is replaced by that of a reference signal. Reference signals do not encode how the eyes move in their orbits, but how they move in space. Hence reference signals are produced not only during eye movements but also during ego-motion, (i.e., in response to vestibular stimulation and to retinal image flow, which may induce vection). The present theory describes how self-motion and object motion percepts interface. Empirical tests (using an experimental paradigm that allows quantitative measurement of the magnitude and gain of reference signals and the size of the Just Noticeable Difference (JND) between retinal and reference signals) reveal that the distinction between direct and inferential theories largely depends on: (1) a mistaken belief that perceptual veridicality is evidence that extraretinal information is not involved, and (2) a failure to distinguish between (the perception of) absolute object motion in space and relative motion of objects with respect to each other. The new model corrects these errors, thus providing a new, unified framework for interpreting many phenomena in the field of motion perception.
URL: http://www.bbsonline.org/Preprints/OldArchive/bbs.wertheim.html
Author Address: wertheim@izf.tno.nl

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Reference Type: Journal Article
Author: Wertheim, A.H.
Year: 1998
Title: Working in a moving environment
Journal: Ergonomics
Volume: 41
Issue: 12
Pages: 1845-1858

Date: December
Number of Pages: 14
Keywords: motion, simulators, work load, task performance, motion sickness
Abstract: The present paper provides a review of research and theories concerning the question of how and why working in a moving environment may affect performance. It is argued that performance decrements can be expected to occur as a result of general factors or as a result of specific impairments of particular human skills. General effects happen when environmental motion, simulated or real, reduces motivation (due to motion sickness), increases fatigue (due to increased energy requirements), or creates balance problems. Specific effects of moving environments on task performance may only be expected through biomechanical influences on particular skills such as perception (interference with oculomotor control) or motor skills (such as manual tracking). There is no evidence for direct effects of motion on performance in purely cognitive tasks.

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Reference Type: Report
Author: Westra, D. P.
Year: 1982
Title: Simulator design features for carrier landing: II. In-simulator transfer of training
City: Orlando, FL
Institution: Naval Training Equipment Center
Date: December
Type: Technical Report
Report Number: NAVTRAEQUIPCEN 81-C-0105-1
Author's Title and Affiliation: Canyon Research Group, Inc., Westlake Village, CA 91361
Number of Pages: 79
Keywords: simulation, carrier landing, transfer of training, field of view, scene detail, motion simulation, holistic design, visual simulation, visual technology research simulator (VTRS)
Abstract: The Visual Technology Research Simulator (VTRS) at the Naval Training Equipment Center was used to study the effects of six factors on carrier-landing training. An in-simulator transfer paradigm was chosen in which students were trained under various conditions and then tested under a standard condition that represented maximum realism. The experimental design permitted a relatively large number of variables to be studied, using a relatively small number of student subjects. The subjects were pilots who had no prior carrier-landing experience: 16 recent graduates of Air Force T-38 training, and 16 highly experienced Navy P-3 pilots.
Display and simulator factors investigated were field of view (160 x 80 vs. 48 X 36 degrees), scene detail (day, solid-surface vs. night, point-light) and platform motion (six-degrees-of-freedom vs. no motion). Two training factors were included: descent-rate cueing (presence or absence of an extra element on the Fresnel lens display that provided information on glideslope descent-rate error), and approach type (training on straight-in approaches vs. circling approaches). Turbulence was included as a factor and pilot type (Navy P-3 vs. Air Force T-38) was also included as a factor to control this source of subject variability. After training under a certain factor-level combination, students were tested on the day, wide field of view, circling task with motion and without descent-rate cueing.
Results showed some temporary transfer advantages for the wide field of view and high scene detail conditions. Training on straight-in approaches resulted in transfer performance that was better than that produced by training on circling approaches. There was no motion or FLOLS rate cueing effects on the transfer task. Display and simulator transfer effects did not differ between the two pilot groups despite large differences in mean group performances.
As a result of these findings, it was suggested that a simulator-to-field transfer study be conducted with field of view, scene detail and approach type as factors. Such a study, using pilots from the target population of undergraduate Naval aviators, would provide the necessary information to make final simulator design decisions for the carrier-landing task.

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Reference Type: Report
Author: Westra, D. P.; Simon, C. W.; Collyer, S. C.; Chambers, W. S.
Year: 1981
Title: Simulator design features for carrier landing: I. Performance experiments
City: Orlando, FL
Institution: Naval Training Equipment Center
Date: December
Type: Interim Report
Report Number: NAVTRAEQUIPCEN 78-C-0060-7
Author's Title and Affiliation: Naval Training Equipment Center
Number of Pages: 62
Keywords: Visual Technology Research Simulator (VTRS), multifactor experiments, holistic experimentation, flight simulation, carrier landing research, visual stimulation, motion simulation
Abstract: The effects of twelve factors on carrier landing performance in the Visual Technology Research Simulator (VTRS) at the Naval Training Equipment Center (NTEC), Orlando, Florida, were investigated in a series of three experiments. Subjects for the experiment were experienced naval aviators. The purpose was to determine and rank order the sizes of effects, identify factors having no effect, and to obtain information for making decisions about future transfer-of-training studies.
[some text was unreadable] experiment, the task was a straight-in approach and landing. Seven visual display factors (Fresnel Lens Optical Landing System type, ship detail, field of view, visual lags, seascape, brightness, TV line rate), two non-visual factors (motion and engine lags), one environmental factor (turbulence) and subjects as a factor were studied. In the second experiment, a circling approach to landing was employed as the task and included as factors ship detail, visual lags, seascape, brightness, motion, and turbulence. In the third experiment, a straight-in approach was employed. Two simulation factors, G-seat and ship type, were studied along with turbulence.
Results generally showed small to null effects for equipment factors although several had statistically reliable effects. As the display and simulator factors were manipulated over a wide range of interest representing expensive vs. inexpensive simulation options, the implication is that simulation for carrier landing skill maintenance and transition training for experienced pilots does not require the highest levels of fidelity for these features. Simulator requirements for training at the undergraduate level are currently being examined.
Notes: See also:
Waag (1981). Training effectiveness of visual and motion simulation.
Westra (1982). Simulator design features for carrier landing: II. In-simulator transfer of training.

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Reference Type: Report
Author: White, Alan D.
Year: 1994
Title: The impact of cue fidelity on pilot behavior and performance
City: Bedford, United Kingdom
Institution: FDS Department, Defence Research Agency
Author's Title and Affiliation: FDS Department, Defence Research Agency, Bedford, United Kingdom
Number of Pages: 12

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Reference Type: Conference Paper
Author: White, A. D.; Hall, J. R.; Tomlinson, B. N.
Year: 1991
Title: Initial validation of an R&D simulator with large amplitude motion
Conference Name: Flight Mechanics Panel Symposium on Piloted Simulation Effectiveness
Conference Location: Brussels, Belgium
Publisher: Advisory Group for Aerospace Research and Development (AGARD)
Date: October 14

Author's Title and Affiliation: Flight Systems Department, Defence Research Agency, Bedford MK41 6AE, United Kingdom
Number of Pages: 24
Keywords: AFS, large amplitude motion, validation
Abstract: The Advanced Flight Simulator (AFS) Complex at DRA Bedford has been enhanced by the addition of a large displacement motion platform and a three channel Computer Generated Image (CGI) outside world visual system. The trial described in this report was the first in a series of trials aimed at validating the AFS in its present configuration and in particular at demonstrating its ability to address a wide range of vehicle handing qualities with a high degree of fidelity and user confidence. It concluded a direct comparison between the ground based AFS and the Calspan Learjet in-flight simulator.
The comparison between the AFS and Learjet involved three pilots flying the same offset approach landing racks using the same aircraft model in both the AFS and in flight. The lateral handling qualities were varied by adjusting the time constant of a filter in the pilots roll control loop. Pilot comments, handling quality and PIO ratings indicate that the AFS reproduces the lateral handling qualities and roll PIO tendencies of the Learjet in-flight simulator with high fidelity. The degradation in handling qualities and increase in PIO tendencies with increasing filter time constant were clearly revealed in both the AFS and Learjet. The importance of good platform motion cueing and task design when evaluation handling qualities was also determined.
Notes: Published in February 1992.

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Reference Type: Conference Paper
Author: White, Alan D.; Rodchenko, Victor V.
Year: 1999
Title: Motion fidelity criteria based on human perception and performance
Conference Name: AIAA Modeling and Simulation Technologies Conference and Exhibit
Conference Location: Portland, OR
Publisher: American Institute of Aeronautics and Astronautics (AIAA)
Date: August 9-11
Electronic Resource Number: AIAA-1999-4330
Author's Title and Affiliation: White: Defence Evaluation and Research Agency (DERA), Bedford, United Kingdom
Rodchenko: Central Aerohydrodynamic Institute (TsAGI), Zhukovsky, Russia
Number of Pages: 9
Abstract: Based on experience accumulated by DERA and TsAGI in developing and using moving-base flight simulators and on the results of recent experiments the following aspects of motion cueing are considered: the role of accelerations in piloting, motion system drive law criteria and the requirements for motion system dynamic performance. The paper presents a theoretical approach to estimating the effect of accelerations, proposes criteria to evaluate motion fidelity for different driving laws and identifies the requirements for motion platform dynamics. Estimates according to the theoretical approach and criteria are compared with the experimental data.

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Reference Type: Conference Paper
Author: White, David
Year: 2000
Title: The future and technology of remote training - 'Bringing training to the pilot'
Conference Name: Flight Simulation - The Next Decade
Conference Location: London, UK
Publisher: Royal Aeronautical Society (RAeS)
Date: May 10-12
Author's Title and Affiliation: Chief Scientist, Thomson Training & Simulation Limited, Crawley, England, RH10 2RL
Number of Pages: 8

Abstract: The advances in Personal Computer (PC) processing power, graphics and network bandwidth are providing an environment that allows the full range of Full Flight Simulator (FFS) functionality & fidelity to be assessed from a laptop PC.
The latest generation of Thomson Training & Simulation (TT&S) Flight Management System Trainers (FMST), Enhanced Situation Awareness Trainers (ESAT) and Cockpit System Trainers (CST) also encompass provision for access via a modem or internet connection. This enables them to be used as 'remote learning and practice' facilities which do not require the pilot to travel to the 'Airline Training Center'.
Since these technologies will no doubt subsequently influence the training methods and type of training equipment delivered in the next decade, this paper discusses the technologies employed, the first feedback from the beta trials and the lessons learned.
During late 1999 TT&S and Honeywell Aviation Services set up a beta site to start testing the principles of remote 'practice'. Initial prototype testing has subsequently confirmed that the PC processing power, graphics and network bandwidth are not a problem. However these issues generated by the variation in network latency 'Jitter' when closing the loop over a commercial Internet Service Provider (ISP) connection, especially over Trans-Atlantic or Trans-Pacific connections, can be somewhat problematic. The emphasis has been on evaluating the technology for use in remote learning and practice at this juncture, the next stage envisages the training community and regulatory bodies assessing the methodology and fidelity of these devices for inclusion in both established and newly generated approved training programs.

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Reference Type: Journal Article
Author: Whiteside, T.C.D.
Year: 1983
Title: Simulators and realism
Journal: Quarterly Journal of Experimental Psychology
Volume: 35A
Pages: 3-15
Number of Pages: 13
Abstract: The objectives of simulation are discussed on the basis of training in procedures or neuromuscular skills, and in relation to the amount of realism required. Motion sickness arising from inadequate coordination of visual and motion cues is considered in relation to fixed and moving base simulators. In the perception of distance and size, the role of ocular convergence is discussed and an experimental approach suggested. The mentally stressful effects of increased responsibility, as robots enable the operator to extend his output, are discussed in relation to its covert symptomatology and to advanced flight concepts.

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Reference Type: Book Section
Author: Wickens, Christopher D.
Year: 1986
Title: The effects of control dynamics on performance
Editor: Boff, Kenneth R.; Kaufman, Lloyd; Thomas, James P.
Book Title: Handbook of Perception and Human Performance
City: New York
Publisher: John Wiley and Sons
Volume: II
Pages: 39.1 - 39.60
Author's Title and Affiliation: Wickens: University of Illinois Institute of Aviation, Aviation Research Laboratory, Savoy, IL
Number of Pages: 60

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Reference Type: Journal Article
Author: Wickens, Christopher D.; Gopher, Daniel
Year: 1977
Title: Control theory measures of tracking as indices of attention allocation strategies
Journal: Human Factors
Volume: 19
Issue: 4
Pages: 349-365
Date: August
Author's Title and Affiliation: Wickens: University of Illinois, Department of Psychology
Gopher: The Technion, Haifa, Israel
Number of Pages: 17
Abstract: In an intelligent man-machine control system, control theory measures describing the operator's tracking performance can provide useful information concerning an operator's attentional state. This information may be used to implement adaptive aiding procedures. Research is reviewed that relates attentional manipulations to variation in control theory parameters, and an experiment is then described in which 29 subjects performed a tracking task alone, and concurrently with a serial reaction-time task. Within the time-sharing condition, relative priorities between the two tasks were manipulated. The results are interpreted in terms of the separate effects of time-sharing and of priority manipulations upon measures of tracking gain, remnant, time-delay and response "holds," and the feasibility of on-line measurement of those variables.

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Reference Type: Journal Article
Author: Wickens, Christopher D.; Small, Ronald L.; Andre, Terence; Bagnall, Timothy; Brenaman, Chris
Year: 2008
Title: Multisensory enhancement of command displays for unusual attitude recovery
Journal: The International Journal of Aviation Psychology
Volume: 18
Issue: 3
Pages: 255-267

Date: July 2008
Number of Pages: 14
Abstract: In a low-fidelity, fixed-base F-16 flight simulator, 12 fighter pilots attempted to recover from unusual pitch-down inverted attitudes. Recovery was done in a control condition, aided by a heads-up display (HUD) only, and with 3 command display augmentations: (a) a command visual icon, pointing in the direction of appropriate control; (b) the icon augmented with a voice command; and (c) the icon augmented with a tactile command. All 3 command displays reduced the time to make the initial recovery response relative to the control condition, and decreased the frequency of initial incorrect roll responses. The tactile and voice augmentations also improved the speed of initial recovery response from the most severe inversions.

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Reference Type: Journal Article
Author: Wightman, Dennis C.; Lintern, Gavan
Year: 1985
Title: Part-task training for tracking and manual control
Journal: Human Factors
Volume: 27
Issue: 3
Pages: 267-283
Number of Pages: 17
Abstract: Part-task training was defined as practice on some set of components of the whole task as a prelude to performance of the whole task. Part-task procedures are intended to improve learning

efficiency and to reduce costs. Our review focused on the instruction of tracking skills for manual control. Transfer of training was emphasized and crucial features of the methodology and of means of assessing transfer were discussed. The part-task procedures of segmentation, fractionation, and simplification were explained, and procedures for reintegrating parts into whole task were summarized.

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Reference Type: Conference Paper
Author: Williams, Kevin W.
Year: 1994
Title: Summary proceedings on the joint industry-FAA conference on the development and use of PC-based aviation training devices
Conference Name: Joint Industry-FAA Conference on the Development and Use of PC-Based Aviation Training Devices
Conference Location: Oklahoma City, OK
Publisher: Federal Aviation Administration (FAA), Civil Aeromedical Institute
Date: June 16-17
Number of Pages: 23
Keywords: personal computer-based aviation training devices, flight training, psychology, applied psychology, memory
Abstract: This report is a summation of the proceedings of a joint industry-FAA conference on the development and use of PC-based aviation training devices (PCATDs) that was held June 16-17 1994 in Oklahoma City, Oklahoma. The primary purpose of the conference was to provide a forum of open dialog among interested PCATD parties, with the aim of finding common ground or areas of consensus, through which progress can be made in reducing or resolving any differences in viewpoint.
Notes: Published in November 1994.

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Reference Type: Report
Author: Williams, Kevin W.
Year: 2001
Title: Qualification guidelines for personal computer-based aviation training devices: Private pilot certificate
City: Oklahoma City, OK
Institution: Federal Aviation Administration (FAA)
Date: July
Type: Final Technical Report
Report Number: DOT/FAA/AM-01/13
Author's Title and Affiliation: FAA Civil Aerospace Medical Institute, P.O. Box 25082, Oklahoma City, OK 73125
Number of Pages: 63
Keywords: PCATD, transfer of training, private pilot training, task analysis
Abstract: As part of the development of qualification guidelines for a personal computer-based aviation training device (PCATD), a task analysis of flight tasks for the private pilot certificate has been completed and is reported in this paper. The primary goal of the task analysis was to identify training device requirements for supporting specific private pilot maneuvers. Before PCATDs can be authorized for use as qualified and approved training devices within a private pilot flight training course, a set of qualification guidelines must be developed for use by the FAA in evaluating such potential training devices. This task analysis constitutes the first steps in the development of those qualification guidelines.
URL: http://stinet.dtic.mil/oai/oai?verb=getRecord&metadataPrefix=html&identifier=ADA396322

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Reference Type: Report
Author: Williams, Kevin W.; Blanchard, Robert E.
Year: 1995
Title: Development of qualification guidelines for personal computer-based aviation training devices
City: Oklahoma City, OK
Institution: Federal Aviation Administration (FAA), Civil Aeromedical Institute
Date: February
Report Number: DOT/FAA/AM-95/6
Number of Pages: 28
Keywords: personal computer-based aviation training devices, flight training, instrument flight, applied psychology
Abstract: Recent advances in the capabilities of personal computers have resulted in an increase in the number of flight simulation programs made available as Personal Computer-Based Aviation Training Devices (PCATDs). The potential benefits of PCATDs have been recognized by researchers and software/hardware developers alike. The purpose of this report is twofold: 1) present a conceptual approach based upon human learning and available flight training data for use in the development and evaluation of PCATDs; and 2) provide a detailed technical plan for an initial effort to develop and test guidelines for assessing the use of PCATDs in a training curriculum of a flight school conducted in accordance with the regulations stated in FAR Part 141.

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Reference Type: Magazine Article
Author: Willingham, Stephen
Year: 2000
Title: Navy seeks balance between simulator and flight training
Magazine: National Defense Magazine
Date: April
Type of Article: Online Article
Number of Pages: 5
Abstract: Future U.S. Navy investments in training programs must focus on the integration of real flying, live-firing exercises and simulators, according to service officials. Such integration is important, these officials asserted, because of the new emphasis in U.S. warfare doctrine on precision bombing and computer network-based technologies.
URL: http://www.nationaldefensemagazine.org/archive/2000/April/Pages/Navy_Seeks4377.aspx

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Reference Type: Magazine Article
Author: Willingham, Stephen
Year: 2000
Title: U.S. Air Force to invest $500 million in simulators through 2006
Magazine: National Defense Magazine
Date: November
Type of Article: Online article
Number of Pages: 2
Abstract: The first big Air Force Indefinite Delivery/Indefinite Quantity (ID/IQ) contract for simulators is the Training System Acquisition (TSA) program, which could be worth up to $500 million. TSA is scheduled to run through 2006.
URL: http://www.nationaldefensemagazine.org/ARCHIVE/2000/NOVEMBER/Pages/US_Air7198.aspx

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Reference Type: Journal Article
Author: Wilson, Barbara A.; Evans, Jonathan J.
Year: 1996
Title: Error-free learning in the rehabilitation of people with memory impairments
Journal: Journal of Head Trauma Rehabilitation
Volume: 11
Issue: 2
Pages: 54-64
Date: 1996
Type of Article: Journal article
Author's Title and Affiliation: Wilson, PhD, Senior Scientist
Evans, Chartered Clinical Psychologist
MRC Applied Psychology Unit, DipClinPsychol
Number of Pages: 11
Abstract: Despite a long tradition of applying techniques of error-free learning in behavioral psychology, used to teach new skills to people with developmental learning disabilities, principles of error-free learning have only recently been explicitly employed in the rehabilitation of people with cognitive deficits acquired later in life. The authors review the studies that have compared error-free with errorful learning methods, discuss the cognitive analysis of error-free learning, and present some criteria for identifying situations in which error-free learning may provide a genuine advantage over trial-and-error learning.

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Reference Type: Report
Author: Wilson, D.
Year: 1965
Title: Visual simulation - Where we are - Where we are going
Institution: Society of Automotive Engineers (SAE)
Pages: 55-59
Date: February 1
Type: Technical Paper
Report Number: SAE TR 670303
Author's Title and Affiliation: General Precision Systems Ltd.
Number of Pages: 5
Abstract: Visual simulation has added a new dimension to flight training simulators. Monochrome TV projection preceded the early color displays which are, in turn, superseded by high definition color systems incorporating features such as full runway and approach lighting.
The paper outlines the progress in visual simulation and high definition color systems which we have today. The requirements of all-weather operation are detailed. New developments are discussed which will further advance the art of visual simulation.

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Reference Type: Magazine Article
Author: Wise, Jeff
Year: 2006
Title: Introducing the airplane of the future
Magazine: Popular Mechanics
Date: July
Keywords: intelligent flight control, refuse-to-crash, upset recovery training (URT)
Abstract: The airplane of the future will be stronger, safer and smarter. With refuse-to-crash technology and radical new flight controls, flying may someday be as easy as driving.
URL: http://www.popularmechanics.com/science/air_space/2932316.html

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Reference Type: Conference Paper
Author: Wolf, John; Gibb, Gerald; Hampton, Steven; Wise, John A.
Year: 1996
Title: An evaluation of full flight simulators and flight training devices in air carrier initial flight training programs
Conference Name: Fifteenth Biennial Applied Behavioral Sciences Symposium
Conference Location: Colorado Springs, CO
Date: April
Author's Title and Affiliation: Embry-Riddle Aeronautical University, Center for Aviation/Aerospace Research, Daytona Beach, FL
Number of Pages: 6
Abstract: The effectiveness of motion in flight simulators used to train and certify pilots is examined. Two groups of pilots were put through two similar training programs: one was a traditional program in which a full flight simulator (FFS)--including motion--was used for all training and certification, and the other program in which a FFS was used only at the final stage to measure pilot skill. This second group (the experimental group) received training in a simulator featuring all of the FFS features (including visual simulation) except motion. Training effectiveness was measured by using the simulator computer to determine the error in pilot control for six maneuvers. A flight instructor rating sheet was also filled out by an independent observer pilot.
Results show no significant difference between the training measures for four of the six maneuvers. In one maneuver, the angle of bank portion of the steep turn maneuver, the control group did perform significantly better than the experimental group. In the visual approach maneuver, however, the experimental group performed better than the control group.
URL: http://home.earthlink.net/~johnwise/wise-delta-dod-paper

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Reference Type: Book
Author: Wood, S. J.
Year: 1995
Title: Airplane flight simulation evaluation handbook
Series Title: International Standards for the Qualifications of Airplane Simulators
City: London
Publisher: Royal Aeronautical Society (RAeS)
Volume: II
Edition: Draft
Keywords: simulator evaluation, subject evaluation
Abstract: Lists methods, evaluations, and discussions on the different training tasks.

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Reference Type: Conference Paper
Author: Woomer, C. W.; Williams, R. L.
Year: 1978
Title: Environmental requirements for simulated helicopter/VTOL operations from small ships and carriers
Conference Name: Flight Mechanics Panel Specialists' Meeting on Piloted Aircraft Environment Simulation Techniques
Conference Location: Brussels, Belgium
Publisher: Advisory Group for Aerospace Research and Development (AGARD)
Date: April 24-27
Author's Title and Affiliation: Woomer: Engineering Test Pilot, US Navy, Rotary Wing Aircraft Test Directorate, Naval Air Test Center, Patuxent River, MD 20670
Williams: Branch Manager, Marketing, Simulation Systems, McDonnell Douglas Electronics Company, Box 426, St. Charles, MO 63301
Number of Pages: 13
Keywords: takeoff and landing tasks, environmental requirements

Abstract: Helicopter/VTOL operations from ships create demanding flying qualities and performance requirements. The environment in which takeoff and landing evolutions must occur has a significant influence on these tasks. Aircraft and simulator designers, each in their own way, must make appropriate provision for environmental factors, such as visual landing aids (VLA), ship motion, turbulence, relative wind, and ground effect.
The unique characteristics of a helicopter combined with the shipboard operations of a naval environment have been successfully simulated in Device 2F106, the SH-2F Weapons System Trainer (WST). It is equipped with a VITAL III computer-generated image (CGI) calligraphic visual system. The development and validation of this device have provided valuable experience on environmental requirements needed to perform takeoff and landing tasks from ships. Technical advances in the state-of-the-art of CGI visual systems now offer capabilities which overcome many previous limitations. This permits additional tasks to be successfully simulated, improving the safety and economics of training.
The paper discusses the specific requirements for the simulated environment to satisfactorily provide training for shipboard takeoff and landing. Test techniques to validate trainer fidelity in flying qualities, performance, and environmental simulation are discussed. The specific subject of calligraphic visual systems is extensively covered including a report on the current state-of-the-art as related to the at-sea environment. Finally, the utilization of a high-fidelity trainer is explored for research as well as for expanded fleet training.

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Reference Type: Web Page
Author: Wright-Patterson Air Force Base
Title: Spatial disorientation in flight
Access Date: March 17, 2003
Description: Spatial Disorientation - Physiological Mechanisms
Keywords: upset recovery training (URT), spatial disorientation, physiological mechanisms
Notes: On 6/14/07, the website was no longer available.

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Reference Type: Web Page
Author: Wuensch, K. L.
Year: 2001
Title: Factorial MANOVA
Publisher: Karl L. Wuensch
Abstract: A factorial MANOVA may be used to determine whether or not two or more categorical independent variables (and their interactions) significantly affect optimally weighted linear combinations of two or more normally distributed dependent variables.
URL: http://core.ecu.edu/psyc/wuenschk/MV/MANOVA/MANOVA2.doc

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Reference Type: Web Page
Author: Wyle Laboratories
Title: Advanced spatial disorientation demonstrator
Access Year: 2002
Access Date: July 27
Keywords: spatial disorientation, upset recovery training (URT)
Abstract: Description of the Wyle Model 2400 Vertifuge advanced spatial disorientation system.
Notes: On 9/30/09, the webpage no longer exists.
URL:
http://www.wylelabs.com/products/aeromedicaltrainingequipmentandfacilities/spatialdisorientationtrainers.html

Reference Type: Conference Paper
Author: Yanus, Thomas M.; Maelstrom, Frederick V.
Year: 1994
Title: Is motion sickness hereditary?
Conference Name: Human Factors and Ergonomics Society, 38th Annual Meeting
Author's Title and Affiliation: Embry-Riddle Aeronautical University
Number of Pages: 5
Keywords: motion sickness, fatigue, headache, nausea, genetics, hereditary
Abstract: Motion Sickness surveys were administered to 77 male graduate students and 95 male and female members of an Air Force Reserve medical unit. Results of Survey 1 indicated significant and sizeable correlations between sons and their natural fathers for severity of motion sickness symptoms of fatigue, headache, and nausea. Stepwise multiple regression indicated that the father's nausea accounted for 59.4% of the total variance of their son's nausea during travel. Results of Survey 2 indicated sizeable and significant correlations between respondents and both natural parents for percentage of reported symptoms of fatigue and headache. Stepwise multiple regression indicated that both parents reported percentage of fatigue (26.6%) and headache (33.6%) reliably predicted the respondents' percentage of fatigue and headache symptoms but not the nausea symptoms. In addition, there were no significant correlations between self-reported symptoms of fatigue, headache, and nausea. Findings suggest (1) hereditary factors may be a significant contributor to motion sickness, both in severity and frequency of symptoms, and (2) fatigue, headache, and nausea are largely independent of each other. Indications are that motion sickness be considered a syndrome rather than a unitary disorder.

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Reference Type: Journal Article
Author: Young, L. R.
Year: 1967
Title: Some effects of motion cues on manual tracking
Journal: Journal of Spacecraft and Rockets
Volume: 4
Issue: 10
Pages: 1300-1303
Date: October
Author's Title and Affiliation: Massachusetts Institute of Technology, Cambridge, MA
Number of Pages: 4
Abstract: Although sustained high acceleration or vibration can have a deleterious effect on a pilot's tracking ability, there are some situations in which motion cues, as felt in flight or moving-base simulation, yield a significant improvement in pilot performance. The first of these situations is in a control task requiring more lead compensation than is easily developed from visual displays. The vestibular and tactile sensations contribute velocity and acceleration information which is used in stabilization. Experiments on control of inverted pendulums and VTOLS with and without motion cues are discussed. Tests of labyrinthine defective patients on similar tasks demonstrated the critical importance of vestibular inputs. The second situation required rapid adaptation to controlled element failures in a simulated blind landing experiment. Other tests showed motion effects to be important in a class of flexible booster control problems. These results were combined with many comparisons of fixed-base-moving-base flight experiments in the literature to arrive at some general conclusions regarding the effects of motion cues on tracking.

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Reference Type: Conference Paper
Author: Young, Laurence R.
Year: 1978
Title: Visually induced motion in flight simulation

Conference Name: Flight Mechanics Panel Specialists' Meeting on Piloted Aircraft Environment Simulation Techniques
Conference Location: Brussels, Belgium
Publisher: Advisory Group for Aerospace Research and Development (AGARD)
Date: April 24-27
Author's Title and Affiliation: Massachusetts Institute of Technology, Man Vehicle Laboratory, Department of Aeronautics and Astronautics, Cambridge, MA 02139
Number of Pages: 8
Keywords: visually induced motion, flight simulation, visual-vestibular interaction, visual cues, circularvection
Abstract: Much of the attention to visual displays for flight simulation in recent years has been devoted toward precision wide field presentations. The significant advances in multiscreen computer image generation and point light source displays have quite literally widened our horizons for presentation of "out-the-window" information. Most attention has been devoted to the precise static display considerations including perspective, grain and contrast. Relatively less attention has been devoted to the dynamic properties of the visual scene and in particular the role of moving wide field presentation in sustaining a pilot's motion sense. This paper addresses the experimental data accumulation on the subject of visually induced motion for all linear and angular degrees of freedom. In particular, we discuss visually induced yaw (circularvection) resulting from a moving wide field presentation, and its interaction with vestibular cues and the low frequency use of visual cues to support sustained angular velocity. The implications for fixed and moving base flight simulator design are discussed. Similar considerations apply to visually induced linear velocity (linearvection) and interesting asymmetries in the fore-aft direction are noted. Finally, visually induced pitch and roll are discussed and modeled in terms of conflict between the visually induced motion and the information regarding attitude based upon graviceptor signals.

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Reference Type: Journal Article
Author: Young, L. R.; Dichgans, J.; Murphy, R.; Brandt, Th.
Year: 1973
Title: Interaction of optokinetic and vestibular stimuli in motion perception
Journal: Acta Otolaryng
Volume: 76
Pages: 24-31
Number of Pages: 8
Abstract: The sensation of self-rotation (circular vection) was produced by rotation of a stripe pattern to the left or to the right at constant angular velocity. During circular vection, subjects were randomly accelerated in constant acceleration steps. The major experimental findings are:
1) Thresholds for detection of angular acceleration are raised when this acceleration is opposite to the direction of circular vection. Times to detect these accelerations are similarly increased.
2) Magnitude estimates of angular velocity show the effect of a visually induced velocity offset which is increased slightly by vestibular responses in the same direction and decreased markedly when the vestibular responses are in the direction opposite to self-rotation.
3) Many of the effects of angular acceleration on perceived velocity are accurately predicted by the adaptation model of the vestibular system. However, an important nonlinear interaction exists whereby rapidly occurring conflicts between visual and vestibular sensation, especially those involving direction disparities, result in precipitous decline in circular vection and temporary domination by the vestibular response.

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Reference Type: Conference Proceedings
Author: Young, L. R.; Oman, C. M.; Curry, R. E.; Dichgans, J. M.
Year of Conference: 1973
Title: A descriptive model of multi-sensor human spatial orientation with applications to visually induced sensations of motion

Conference Name: AIAA Visual and Motion Simulation Conference
Conference Location: Palo Alto, CA
Publisher: American Institute of Aeronautics and Astronautics (AIAA)
Pages: 1-4
Date: September 10-12
Electronic Resource Number: AIAA 73-915
Author's Title and Affiliation: Young, Oman, Curry: Massachusetts Institute of Technology, Cambridge, MA
Dichgans: Neurologische Universitatsklinik, Freiburg, West Germany
Number of Pages: 4
Keywords: multi-sensor human spatial orientation, visually induced sensations to motion, vestibular sensors, circularvection, exteroceptive tactile information, upset recovery training (URT)
Abstract: The physiological systems underlying human sensation of spatial orientation and postural control are of particular interest from a control point of view and are reviewed in the first part of the paper. The second part of the paper summarizes recent experiments investigating visually induced motion sensations.

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Reference Type: Conference Proceedings
Author: Zaal, P.M.T.; Pool, D.M.; De Bruin, J.; Mulder, M.; Van Paassen, M.M.
Year of Conference: 2008
Title: Pilots' use of pitch and heave motion cues in a pitch control task
Conference Name: AIAA Modeling and Simulation Technologies Conference
Conference Location: Honolulu, HI
Publisher: American Institute of Aeronautics and Astronautics (AIAA)
Date: August 18-21
Electronic Resource Number: AIAA 2008-6537
Author's Title and Affiliation: Control and Simulation Division, Faculty of Aerospace Engineering, Delft University of Technology, Delft, The Netherlands
Abstract: During pitch rotation of the aircraft, a pilot, seated well in front of the aircraft center of gravity, is subjected to rotational pitch and vertical heave motion. The heave motion is a combination of the vertical motion of the aircraft center of gravity and heave motion as a result of the pitch rotation. In a pitch tracking task all of these cues could potentially have a positive effect on performance and control behavior, as they are all related to the aircraft pitch attitude. In order to improve the tuning of flight simulator motion filters, a better understanding of how these motion components are used by the pilot is required. First, the optimal use of the different motion components was evaluated using an optimal control analysis. Next, an aircraft pitch attitude control experiment was performed in the SIMONA Research Simulator, investigating the effects of pitch rotation, pitch heave and center of gravity heave on pilot control behavior. Pilot performance significantly improved with pitch motion, with an increased cross-over frequency for the disturbance open-loop. The increase in performance was a result of an increased visual gain and a reduction in visual lead, allowed for by the addition of motion cues. Pitch heave motion showed similar but smaller effects. The center of gravity heave motion, although taking up most of the simulator motion space, was found to have no significant effects on performance and control behavior.
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Reference Type: Journal Article
Author: Zacharias, G. L.; Young, L. R.
Year: 1981
Title: Influence of combined visual and vestibular cues on human perception and control of horizontal rotation
Journal: Experimental Brain Research
Volume: 41
Pages: 159-171
Author's Title and Affiliation: Man Vehicle Laboratory, Department of Aeronautics and Astronautics, Massachusetts Institute of Technology, Cambridge, MA 02139
Number of Pages: 13
Keywords: vestibular, motion perception, visual-vestibular interaction, manual control
Abstract: Measurements are made of manual control performance in the closed-loop task of nulling perceived self-rotation velocity about an earth-vertical axis. Self-velocity estimation is modeled as a function of the simultaneous presentation of vestibular and peripheral visual field motion cues. Based on measured low-frequency operator behavior in three visual field environments, a parallel channel linear model is proposed which has separate visual and vestibular pathways summing in a complementary manner. A dual-input describing function analysis supports the complementary model; vestibular cues dominate sensation at higher frequencies. The describing function model is extended by the proposal of a non-linear cue conflict model, in which cue weighting depends on the level of agreement between visual and vestibular cues.

Reference Type: Conference Paper
Author: Zahorik, P.; Tam, C.; Wang, K.; Bangayan, P.; Sundareswaran, V.
Year: 2001
Title: Localization accuracy in 3-D sound displays: The role of visual-feedback training
Conference Name: Advanced Displays Consortium: ARL's 5th Federated Laboratory Annual Symposium
Author's Title and Affiliation: P. Zahorik: Department of Psychology, University of California - Santa Barbara, Santa Barbara, CA 93106-9660
C. Tam, K. Wang, P. Bangayan, & V. Sundareswaran: Rockwell Science Center, 1049 Camino Dos Rios, Thousand Oaks, CA 91360
Number of Pages: 6
Abstract: Using an inexpensive headphone-based 3-D sound display, sound localization accuracy was assessed for six listeners, before, during, and after a perceptual feedback training procedure which provided listeners with paired auditory/visual feedback as to the correct sound source position. We show that feedback training markedly improved localization accuracy, with the largest improvements resulting from listener's enhanced abilities to distinguish sources in front from sources behind. Further, these improvements were not transient short-term effects, but appear to last a number of days between training and testing sessions. These results suggest that simple and relatively short periods of perceptual training can effectively mitigate technical deficiencies in low-cost 3-D sound systems due to the use of non-individualized head-related transfer functions.
URL: http://www.recveb.ucsb.edu/pdfs/ZahorikEtAl01.pdf

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Reference Type: Conference Proceedings
Author: Zaichik, L.; Yashin, Y.; Desyatnik, P.
Year of Conference: 2009
Title: Motion fidelity criteria for large-amplitude tasks
Conference Name: AIAA Modeling and Simulation Technologies Conference
Conference Location: Chicago, IL
Publisher: American Institute of Aeronautics and Astronautics (AIAA)
Pages: 1-11
Date: Aug. 10-13
Electronic Resource Number: AIAA-2009-5916
Author's Title and Affiliation: Zaichik: Head of Section, PhD, Central Aerohydrodynamic Institute, Zhukovsky, Russia
Yashin: Leading Research Engineer, PhD, Central Aerohydrodynamic Institute, Zhukovsky, Russia
Desyatnik: Engineer, Central Aerohydrodynamic Institute, Zhukovsky, Russia
Number of Pages: 11
Keywords: large-aplitude (LA) piloting tasks, distortions, motion fidelity, roll acceleration, vertical specific force
Abstract: Useful cockpit motion cues in ground-based simulation are challenging to produce due to necessary constraints on motion workspace. Fidelity of the motion cues provided is similarly challenging to assess. Pilots' use of motion cues differs for different piloting tasks. In particular, large amplitude maneuvering tasks present motion cueing challenges which are different from those for small amplitude stabilization tasks.
This paper considers the effects of distortions caused by cockpit drive algorithms while simulating the large-amplitude (LA) piloting tasks of transport aircraft; the causes of the distortions are determined and analyzed. Further, criteria are developed to assess motion fidelity in reproducing roll accelerations and vertical specific forces in LA tasks.To substantiate the criteria, the results of the series of theoretical and experimental studies are used.

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Reference Type: Conference Paper
Author: Zaichik, L. E.; Rodchenko, V. V.; Rufov, I. V.; Yashin, Y. P.; White, A. D.
Year: 1999
Title: Acceleration perception
Conference Name: AIAA Modeling and Simulation Technologies Conference and Exhibit
Conference Location: Portland, OR
Publisher: American Institute of Aeronautics and Astronautics (AIAA)
Date: August 9-11
Electronic Resource Number: AIAA-1999-4334
Author's Title and Affiliation: Zaichik, Rodchenko, Rufov, Yashin: Central Aerohydrodynamic Institute (TsAGI), Handling Qualities and Flight Simulation Section, Zhukovsky, Russia
White: Defence Evaluation and Research Agency (DERA), Bedford, UK
Number of Pages: 19
Abstract: The results of simulator experiments on acceleration perception using a 6-dof motion platform are presented and compared with previously published data. The roles of different sensory systems (vestibular, kinesthetic, tactile) in perception of the accelerations are analyzed and acceleration perception math-models are discussed. Absolute and differential sensitivity thresholds are determined for sinusoidal accelerations of different frequencies and the influence of different factors on the threshold values is estimated. The laws governing the perception of acceleration over-threshold values are substantiated.

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Reference Type: Conference Paper
Author: Zaichik, L. E.; Rodchenko, V. V.; Yashin, Y. P.; Rufov, I. V.; White, A. D.
Year: 2000
Title: A theoretical approach to estimation of acceleration effects on piloting
Conference Name: AIAA Modeling and Simulation Technologies Conference and Exhibit
Conference Location: Denver, CO
Publisher: American Institute of Aeronautics & Astronautics (AIAA)
Date: August 14-17
Electronic Resource Number: AIAA-2000-4295
Author's Title and Affiliation: Zaichik, Rodchenko, Yashin, & Rufov: TsAGI, Moscow, Russia
White: Defence Evaluation and Research Agency, Farnborough, United Kingdom
Abstract: The paper presents an analysis, based on experimental data, of the effects od acceleration on pilot ratings and performance for various piloting tasks and aircraft characteristics. These acceleration effects are discussed and a theoretical approach to the estimation of these effects for different aircraft and control axes is proposed and substantiated. The effectiveness of the approach is illustrated by an analysis of the effects of acceleration on roll control.

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Reference Type: Conference Proceedings
Author: Zaychik, Kirill; Cardullo, Frank; George, Gary; Kelly, Lon C.
Year of Conference: 2009
Title: Evaluating effectiveness of modeling motion system feedback in the enhanced Hess Structural Model of the human operator
Conference Name: AIAA Modeling and Simulation Technologies Conference
Conference Location: Chicago, IL
Publisher: American Institute of Aeronautics and Astronautics (AIAA)
Pages: 1-14
Date: Aug. 10-13
Electronic Resource Number: AIAA-2009-6032
Author's Title and Affiliation: Zaychik: Graduate Student, Man-Machine Systems Laboratory, Department of Mechanical Engineering, SUNY Binghamton, Binghamton, NY

Cardullo: Professor, Man-Machine Systems Laboratory, Department of Mechanical Engineering, SUNY Binghamton, Binghamton, NY
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Kelly: Software Engineer, Unisys Corp, Hampton, VA
Number of Pages: 14
Keywords: Hess Structural Model, motion system dynamics, motion cueing algorithm, vestibular system, motion feedback
Abstract: In order to use the Hess Structural Model to predict the need for certain cueing systems, George and Cardullo significantly expanded it by adding motion feedback to the model and incorporating models of the motion system dynamics, motion cueing algorithm and a vestibular system. This paper proposes a methodology to evaluate the effectiveness of these innovations by performing a comparison analysis of the model performance with and without the expanded motion feedback.
The proposed methodology is composed of two stages. The first stage involves fine-tuning parameters of the original Hess structural model in order to match the actual control behavior recorded during the experiments at NASA Visual Motion Simulator (VMS) facility. The parameter tuning procedure utilizes a new automated parameter identification technique, which was developed at the Man-Machine Systems Lab at SUNY Binghamton. In the second stage of the proposed methodology, an expanded motion feedback is added to the structural model. The resulting performance of the model is then compared to that of the original one. As proposed by Hess, metrics to evaluate the performance of the models include comparison against the crossover models standards imposed on the crossover frequency and phase margin of the overall man-machine system. Preliminary results indicate the advantage of having the model of the motion system and motion cueing incorporated into the model of the human operator. It is also demonstrated that the crossover frequency and the phase margin of the expanded model are well within the limits imposed by the crossover model.

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Reference Type: Conference Proceedings
Author: Zaychik, Kirill B.; Cardullo, Frank M.
Year of Conference: 2007
Title: Genetic algorithm based approach for parameters estimation of the Hess operator model
Conference Name: AIAA Modeling and Simulation Technologies Conference and Exhibit
Conference Location: Hilton Head, SC
Publisher: American Institute of Aeronautics and Astronautics (AIAA)
Date: August 20-23
Electronic Resource Number: AIAA 2007-6893
Author's Title and Affiliation: Zaychik: PhD Candidate, Department of Mechnaical Engineering
Cardullo: Professor, Department of Mechanical Engineering and on sabbatical at Delft University of Technology
State University of New York at Binghamton, Binghamton, NY 13902-6000
Abstract: In the 2006 MSTC paper on operator modeling (A Conspectus on Operator Modeling: Past, Present and Future), the authors laid the theoretical foundation for the prospective methodology of the real-time estimation of operator modeling parameters. The proposed approach heavily relies on hybrid intelligent computing techniques, including neural networks, fuzzy interference systems and genetic algorithms. This paper addresses the first part of the approach which is to identify the parameters of a human operator model, which is necessary to establish a data base to be used in the real-time application. Such an approach is categorized as a data driven model, which implies that time histories of the input/output data are available. In the case of the operator model, this relationship is given by the disturbance and the operator control as predicted by the Hess structural model. The primary task of the current investigation was to devise a methodology, which would automatically identify parameters of the Hess model given the knowledge of the input disturbance and actual (real) operator behavior. The identification process is accomplished by searching for a combination of the Hess model parameters that would drive the model response to match the actual operator behavior. The search engine utilized by the proposed methodology is based on the Genetic Algorithm, (GA) concept, - a powerful soft computing technique, often used as an alternative to conventional optimization algorithms. Preliminary, non-real-time

results presented in this paper demonstrate high efficiency of the proposed methodology. The estimated parameters are in good correlation with the nominal values: the estimation error is 0% in its minimum, and 15% in its maximum. Time domain comparison shows an exact match of the estimated and actual operator control signals. These results are accompanied by the appropriate graphs and tables.

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Reference Type: Conference Paper
Author: Zeyada, Y.; Hess, R. A.
Year: 1999
Title: A methodology for evaluating the fidelity of ground-based flight simulators
Conference Name: AIAA Modeling and Simulation Technologies Conference and Exhibit
Conference Location: Portland, OR
Publisher: American Institute of Aeronautics and Astronautics (AIAA)
Date: August 9-11
Electronic Resource Number: AIAA 1999-4034
Author's Title and Affiliation: Department of Mechanical and Aeronautical Engineering, One Shields Avenue, University of California, Davis, CA 95616-5294
Number of Pages: 17
Abstract: An analytical and experimental investigation was undertaken to model the manner in which pilots perceive and utilize visual, proprioceptive, and vestibular cues in a ground-based flight simulator. The study was part of a larger research effort which has the creation of a methodology for determining flight simulator fidelity requirements as its ultimate goal. The study utilized a closed-loop feedback structure of the pilot/simulator system which included the pilot, the cockpit inceptor, the dynamics of the simulated vehicle and the motion system. With the exception of time delays which accrued in visual scene production in the simulator, visual scene effects were not included in this study. The NASA Ames Vertical Motion Simulator was used in a simple, single-degree of freedom rotorcraft bob-up/down maneuver. Pilot/vehicle analysis and fuzzy-inference identification were employed to study the changes in fidelity which occurred as the characteristics of the motion system were varied over five configurations. The data from three of the five pilots that participated in the experimental study were analyzed in the fuzzy-inference identification. Results indicated that both the analytical pilot/vehicle analysis and the fuzzy-inference identification can be used to reflect changes in simulator fidelity for the task examined.

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Reference Type: Journal Article
Author: Zeyada, Y.; Hess, R.A.
Year: 2000
Title: Modeling human pilot cue utilization with applications to simulator fidelity assessment
Journal: Journal of Aircraft
Volume: 37
Issue: 4
Pages: 588-597
Date: July-August
Author's Title and Affiliation: University of California, Davis California
Number of Pages: 10
Abstract: An analytical investigation to model the manner in which pilots perceive and utilize visual, proprioceptive, and vestibular cues in a ground-based flight simulator was undertaken. Data from a NASA Ames Research Center vertical motion simulator study of a simple, single-degree-of-freedom rotorcraft bob-up/down maneuver were employed in the investigation. The study was part of a larger research effort that has the creation of a methodology for determining flight simulator fidelity requirements as its ultimate goal. The study utilized a closed-loop feedback structure of the pilot/simulator system that included the pilot, the cockpit inceptor, the dynamics of the simulated vehicle, and the motion system. With the exception of time delays that accrued in visual scene production in the simulator, visual scene effects were not included in this study. Pilot/vehicle analysis and fuzzy-inference identification were employed to study the changes in fidelity that occurred as the characteristics of the motion system were varied over

five configurations. The data from three of the five pilots who participated in the experimental study were analyzed in the fuzzy-inference identification. Results indicate that both the analytical pilot/vehicle analysis and the fuzzy-inference identification can be used to identify changes in simulator fidelity for the task examined.

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Reference Type: Journal Article
Author: Zeyada, Y.; Hess, R. A.
Year: 2003
Title: Computer-aided assessment of flight simulator fidelity
Journal: Journal of Aircraft
Volume: 40
Issue: 1
Pages: 179-180
Date: January-February
Author's Title and Affiliation: University of California, Davis, CA 95616-5294
Number of Pages: 8
Abstract: A technique for computer-aided assessment of flight simulator fidelity is presented. The assessment procedure utilizes a mathematical model of the human pilot that includes proprioceptive, visual, and vestibular cues. The quality of the latter two cues can be varied to capture the effects of flight simulator limitations associated with visual and motion cueing. A MATLAB-based tool that automates the selection of the majority of parameters in the pilot model and the generation of a fidelity metric is described. In addition, a prediction of the task-dependent handling qualities of the nominal flight vehicle can be obtained. The assessment procedure is exercised in a hypothetical example involving the six-degree-of-freedom control of a rotorcraft completing a vertical remask maneuver. It is demonstrated that by varying the quality of the visual and vestibular cues in the pilot/vehicle model the effects of simulator limitations upon fidelity can be systematically addressed.

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