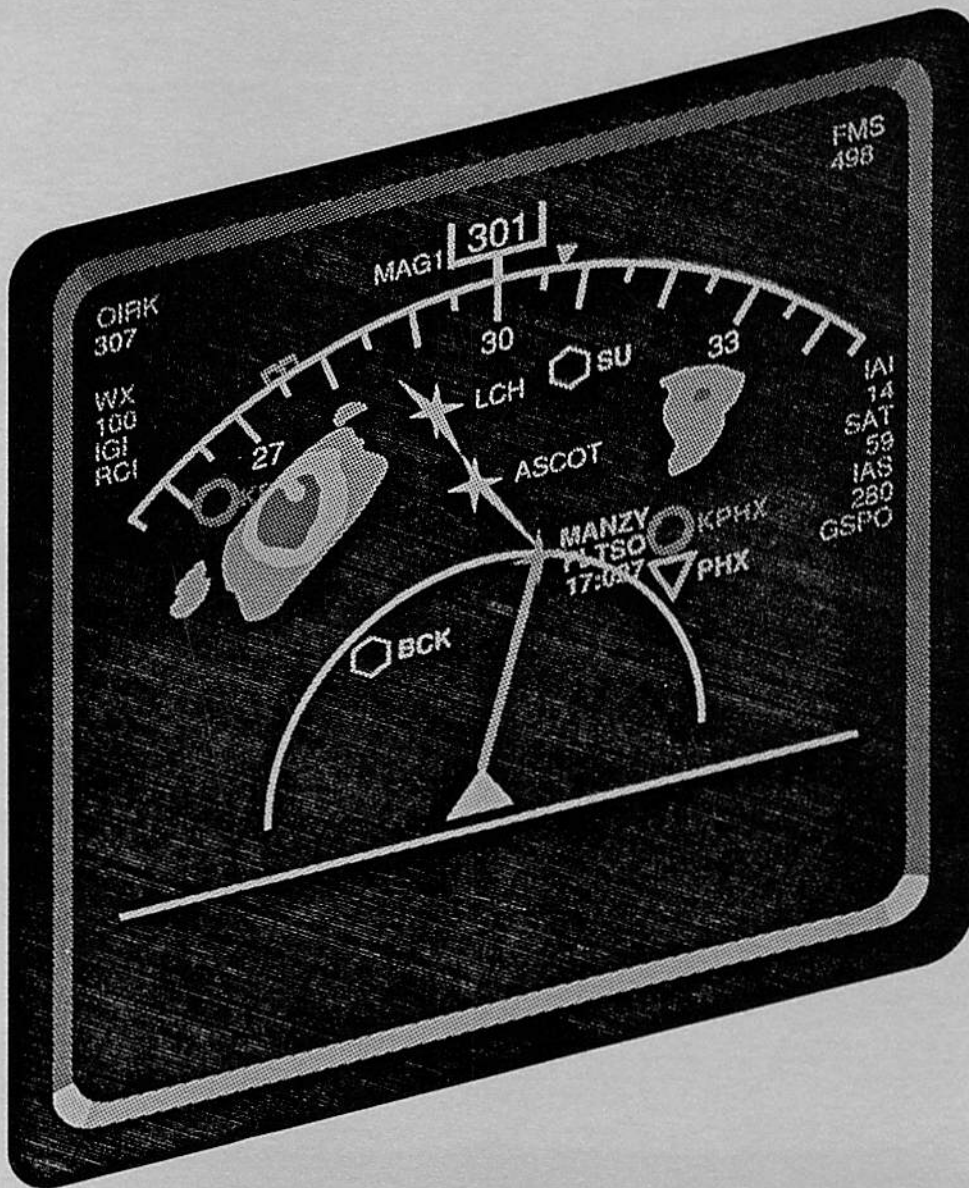


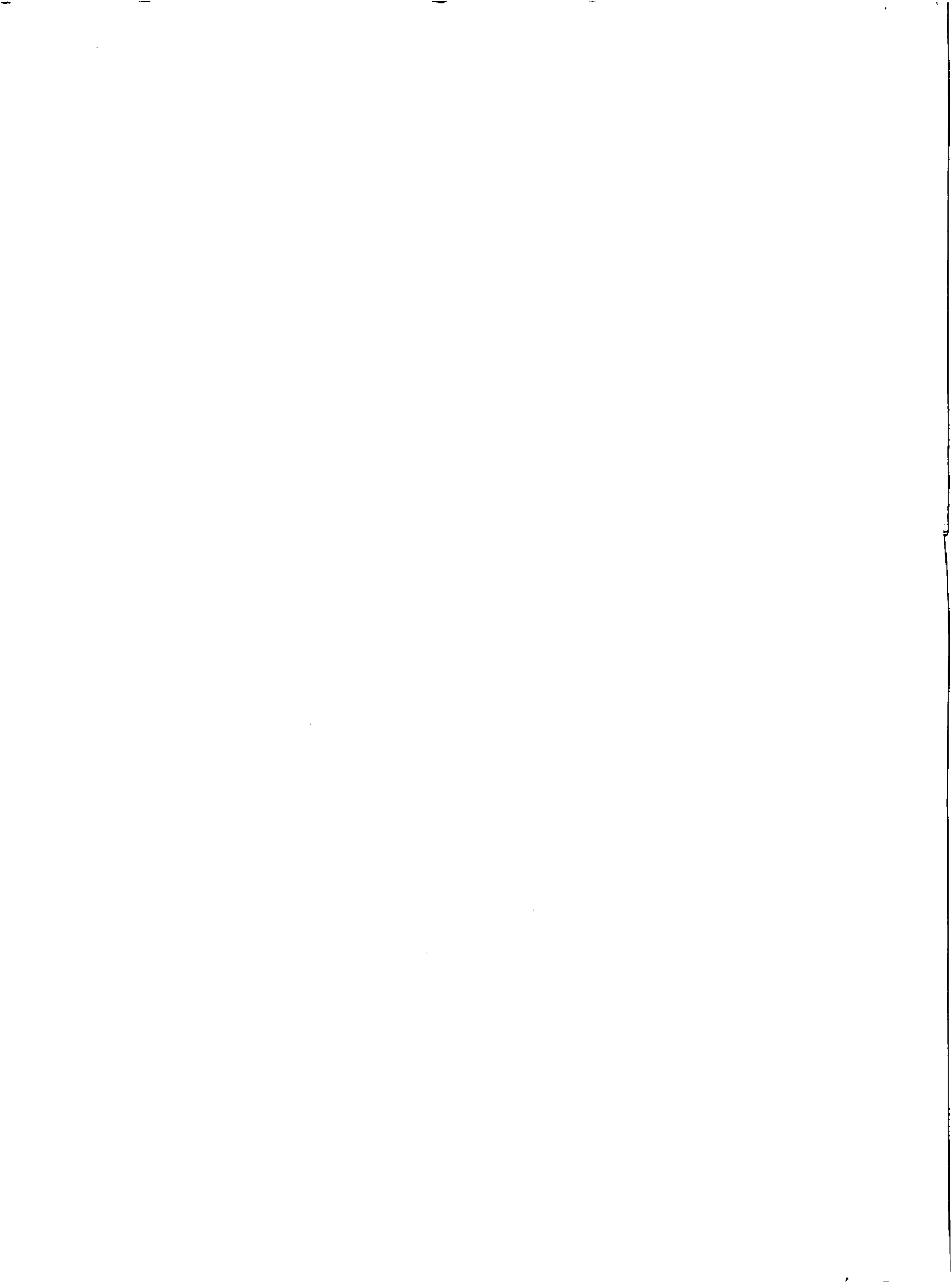


U.S. Department
of Transportation

Federal Aviation
Administration

COCKPIT HUMAN FACTORS RESEARCH REQUIREMENTS





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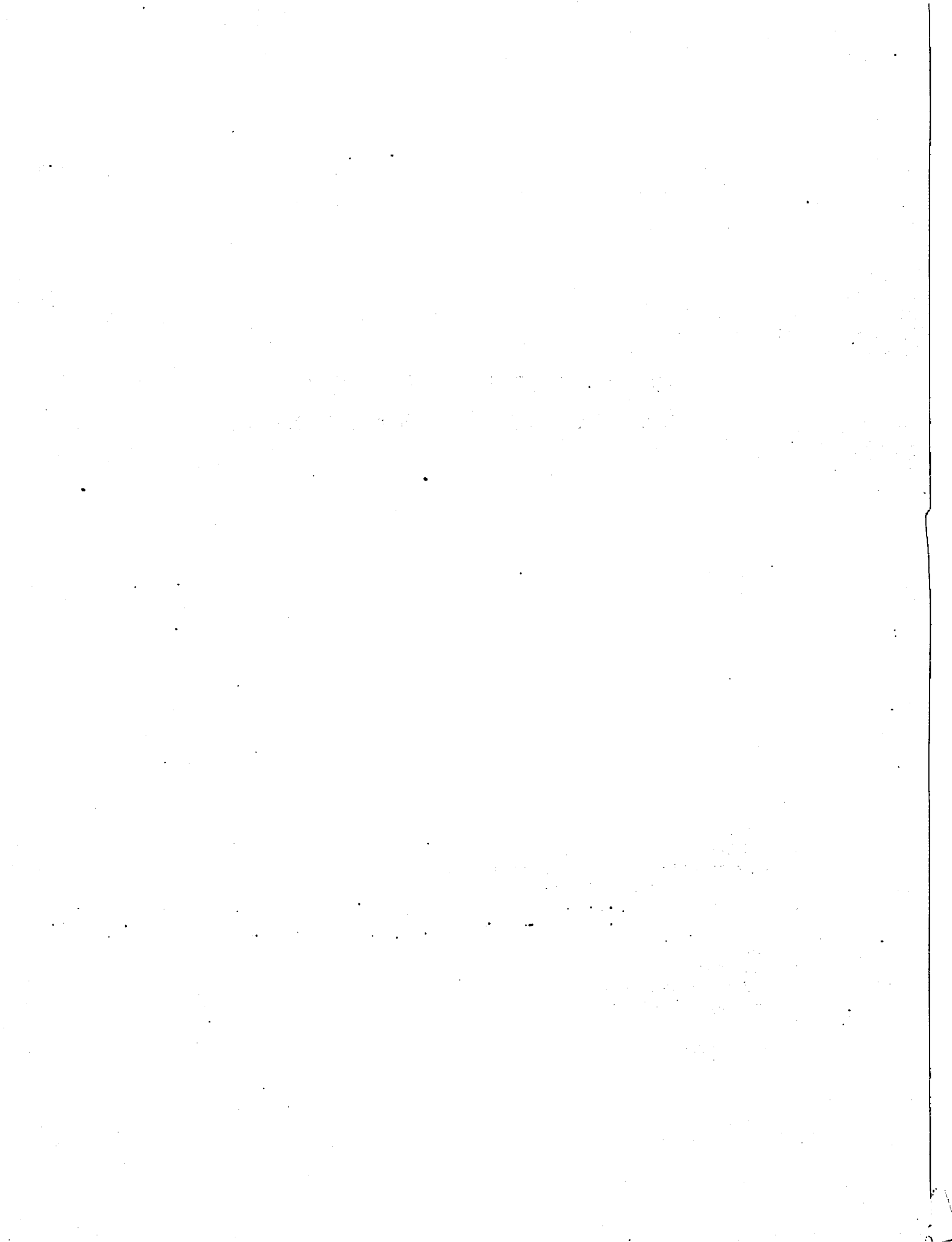


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Cockpit Human Factors Research Requirements

EXECUTIVE SUMMARY

The safety, reliability, and efficiency of the National Airspace System (NAS) depend upon the men and women who operate and use it. Aviation human factors research is the study of how people function in the performance of their jobs as pilots, controllers, maintenance, and ground support personnel. Increasing automation and system complexity are placing new and different demands on the staff of the nation's air transportation system. Concern over human performance in safety has been raised in Congress, industry and the academic community. Recently, special attention has been placed on both the air traffic control (ATC) system and flight deck operations.

In the past, with a few notable exceptions, such as Traffic Alert and Collision Avoidance System (TCAS) and Ground Proximity Warning System (GPWS), the development and application of new aviation system technology both in the ATC and flight systems has been directed toward increasing the traffic capacity of the NAS, rather than being directed primarily toward the improvement of flight safety. The present program is intended to develop and apply advanced behavioral analysis and technology specifically toward the advancement of flight safety.

Pilot error has been identified as a causal factor in 66 percent of air carrier fatal accidents, 79 percent of commuter fatal accidents, and 88 percent of the general aviation fatal accidents. FAA is concerned with the causal factors these statistics represent and the trends that they reflect. FAA recognizes the importance of a better understanding and greater consideration of the human factors aspect of aviation.

The research requirements presented in this document update those presented in the 1985 *Cockpit Human Factors Research Plan*. The requirements presented in the 1985 plan were identified primarily through a series of six FAA-sponsored workshops held specifically for that purpose. These workshops revealed 137 cockpit-related human performance problem areas that could be addressed through human factors research. A subset of these 137 items were selected by the FAA as being particularly important to aviation safety. The members of the Society of Automotive Engineers' Committee on Aerospace Behavioral Engineering Technology reviewed this subset of issues and concurred on their importance.

This document represents a formal programmatic commitment of the Federal Aviation Administration to address human performance-related aviation safety issues. It provides a single source of the requirements for the cockpit-related human factors research that should be conducted or sponsored by the FAA and the FAA offices that have a special interest in the work. These requirements will be considered in the research and development process and budget, and will become the nucleus of a FAA human factors research plan that will include areas outside the cockpit (such as air traffic control and maintenance). The

development and identification of research priorities will continue and will actively involve a broad aviation constituency including government officials, manufacturers, airline operators, labor and trade organizations, researchers, and public interest groups. The schedules and details of active research projects identified in this document may be found in the *Federal Aviation Administration Plan for Research, Engineering and Development*.

The following are the 24 research requirements identified in this document:

- 1.** Determine whether cockpit flight data information systems are designed to promote and facilitate the detection by flight crews of the need to intervene in the automated control of aircraft and to fly them manually if required.
- 2.** Determine the extent to which the use of automated systems may degrade a pilot's ability to fly manually. Determine the training and checking necessary to ensure maintenance of manual skills required in the event of the failure of automated flight systems.
- 3.** Identify the information required by aircrews to fly commercial aircraft safely in the evolving NAS.
- 4.** Develop guidelines for the design and criteria for the evaluation of cockpit displays regarding their efficiency of use by flight crews.
- 5.** Determine the advantages and disadvantages of standardizing cockpit displays, controls and procedures.
- 6.** Establish human performance checklists for use by procedure specialists and flight inspection pilots for the development of instrument approach procedures, SID's (Standard Instrument Departures, noise abatement procedures) and STARS (Standard Terminal Arrival Procedures) that would improve the speed and accuracy of information transfer.
- 7.** Improve the design of instrument procedure charts to facilitate the speed and accuracy of the transfer of information to flight crews.
- 8.** Identify weather information requirements of pilots, and increase the efficiency with which this information is delivered to the flight crew.
- 9.** Develop criteria based on flight crew performance for evaluating new cockpit displays, controls, and procedures designed to reduce helicopter pilot workload in IMC.
- 10.** Develop guidelines for the use of voice-activated flight management systems in the aircraft cockpits; develop system performance criteria for certification.

- 11.** Develop equipment standards and operational procedures for use with digital data input devices to minimize pilot error. Develop requirements for training flight crews in the use of these devices.
- 12.** Develop intra-agency design review requirements and evaluation methods to ensure that the modernization of the NAS, automation and related changes in cockpit design do not influence pilot workload to the detriment of flight safety.
- 13.** Develop certification criteria for advanced technology cockpits that are based upon objective measures of crew performance.
- 14.** Determine what ranges of aircrew workload are consistent with acceptable levels of performance and develop strategies for coping with workload extremes.
- 15.** Develop a human factors training program for FAA pilots and engineers involved in the human performance evaluation of flight deck displays and controls.
- 16.** Develop, coordinate, and maintain a program dedicated to identifying the causes of pilot error.
- 17.** Identify the characteristics of automated flight management systems that influence or contribute to their compatibility with human operators.
- 18.** Determine the effects of fatigue on crew interaction and develop countermeasures to alleviate adverse affects.
- 19.** Improve flight crew training by incorporating the principles of cockpit resource management (CRM) and increasing the effectiveness of line-oriented flight training (LOFT).
- 20.** Develop and evaluate training materials and evaluation techniques for improving pilot judgement and decision making.
- 21.** Determine minimum levels of simulator fidelity and instruction required to achieve selected training objectives
- 22.** Identify the extent to which inexpensive simulators and part-task trainers can be utilized in the training of pilots.
- 23.** Increase the effectiveness of simulator training for developing and maintaining flying proficiency.
- 24.** Ensure that criteria for the selection, training, and certification of airmen reflect current and anticipated knowledge, skills, and abilities necessary to satisfy the operational requirements of the increasingly complex flight environment.

Cockpit Human Factors Research Requirements

1.0 INTRODUCTION

1.1 HISTORY

Since the early years of World War II, it has been recognized that the limiting factor in the effectiveness of human-machine systems has been not the mechanical or electronic characteristics of the system, but the ability of the human to manage and operate it correctly. For the entire period of the war and for a number of years afterward, the demands of the systems outstripped the abilities of the human operators, mainly because the systems were not designed within the bounds of human capabilities and limitations. The dilemma was well described in the title of a post-war paper by the renowned psychophysicist S.S. Stevens: "Machines Cannot Fight Alone" (1946).

With the end of the war, most of the psychologists who had pioneered in the new field of human engineering, as it was called then, continued their work either in government service or at universities. The lessons of complex systems and limited humans learned so painfully during the war were not forgotten, and the field now known as human factors or human factors engineering emerged and grew rapidly. For example, the Human Factors Society formed by a small group between 1955 and 1957 has grown to a membership of almost 5000. Much of the work continued to address aircraft and space applications. Military aircraft predominated, but in recent years there has been an increase in research activity directed toward civil aircraft, mostly air carriers. General aviation and helicopters have received relatively little attention. A historical review of aviation human factors can be found in Edwards (1988).*

In the last two decades there has been a dramatic improvement in the safety record of air carriers worldwide, and particularly in the U.S. This has largely been due to vast improvements in materials, structures, and manufacturing, which were responsible for a large measure of the accidents in the past. Human factors has also played a part in the reduction of accidents, but has barely been able to keep up with the rapid advances in aircraft speed, performance, and complexity, the demands of an over-taxed air traffic control (ATC) system, and more recently the special demands wrought by the hub-and-spoke system, a by-product of the Airline Deregulation Act of 1978. The net result of these trends has been that human error was involved in about 65-70 percent of all airline accidents (Sears, 1986; Nagel, 1988). In his testimony before the House Subcommittee on Transportation, Aviation, and Materials, Wiener (1988b) stated that "human factors is the last frontier of aviation safety." He further testified, "it is high time that human factors be elevated to the status of a 'core technology', along with structures, materials, etc." (See also Office of Technology Assessment, 1988.)

*See Bibliography

1.2 BACKGROUND

The research requirements presented in this document update those presented in the 1985 *Cockpit Human Factors Research Plan*. The requirements presented in the 1985 plan were identified primarily through a series of six FAA-sponsored workshops held specifically for that purpose. These workshops revealed 137 cockpit-related human performance problem areas that could be addressed through human factors research. A subset of these 137 items were selected by the FAA as being particularly important to aviation safety. The members of the Society of Automotive Engineers' Committee on Aerospace Behavioral Engineering Technology reviewed this subset of issues and concurred on their importance.

This document represents a formal programmatic commitment of the Federal Aviation Administration to address human performance-related aviation safety issues. It provides a single source of the requirements for the cockpit-related human factors research that should be conducted or sponsored by the FAA and the FAA offices that have a special interest in the work. These requirements will be considered in the research and development process and budget, and will become the nucleus of a FAA human factors research plan that will include areas outside the cockpit (such as air traffic control and maintenance). The development and identification of research priorities will continue and will actively involve a broad aviation constituency including government officials, manufacturers, airline operators, labor and trade organizations, researchers, and public interest groups. The schedules and details of active research projects that address requirements in this document may be found in the *Federal Aviation Administration Plan for Research, Engineering and Development*.

1.3 CIVIL AVIATION HUMAN FACTORS ACTIVITIES OUTSIDE THE FAA

The importance of promoting human factors research in aviation has been recognized by Congress. The Aviation Safety Research Act of 1988 (Public Law 100-591) directs the FAA to conduct human factors research and authorizes the expenditure of 25 million dollars in Fiscal Year 1990 for human factors research projects and activities.

There are several groups outside of the FAA that are concerned with the development and execution of aviation human factors projects. Their activities represent concerns within the aviation community about the importance of designing and operating flight systems consistent with the human operator's limits and capabilities for doing so safely, and for the apparent lack of standards and guidelines that are believed to be available for this purpose. These groups are particularly notable because of their participants' expertise and standing within the aviation community and their potential for influencing national research priorities.

The Air Transport Association (ATA) has developed a plan for increasing flight safety through human factors research and related activities. The issues raised in this plan range from the development of new display technology to the identification of ATC applications for data link. All of the issues specified in the ATA plan are, to some extent, addressed in this requirements document.

The Joint Government Industry Task Force on Flight Crew Performance was formed by ATA during September 1987 at the request of FAA Administrator McArtor to research and operations safety issues concerning crew performance that should be addressed during his tenure. Three technical subcommittees were formed from the task force to address issues concerned with flight operations, crew training, and man/machine interface design. Each of these subcommittees was charged with recommending actions that could be taken by the Administrator to improve flight safety. The recommendations made to date include several issues that are represented in both this document and the *ATA National Plan to Enhance Aviation Safety through Human Factors Improvements*.

Human factors scientists at the NASA - Ames Research Center have generated a list of human factors activities that they consider to be important to flight safety. The projects described are either underway or ones that they would like to initiate. Where work at NASA-Ames, or any other research organization, is known to be related to the requirements presented in this document, it will be noted in the REMARKS section of the appropriate abstract.

1.4 SPECIFIC APPLICATION AREAS

1.4.1 Aircraft Automation

With the rapid introduction of cockpit automation, much has been written in the last decade about the impact of advancing technology on the role of the pilot (Wiener and Curry, 1980; Wiener, 1988a; Chambers and Nagel, 1985).

Automation in the cockpit has been considered a mixed blessing by scientists and pilots alike. Wiener and Curry (1980) referred to the "promises and problems" of automation and gave numerous examples of each. On the positive side, automation offers precise navigation (and thus the potential for conservation of airspace), fuel efficient flight paths and power plant control, and modern warning and alerting systems. On the other hand, automation has not fulfilled its promises to reduce pilot workload and decrease the probability of pilot error. Automation often increases cognitive workload as it reduces manual workload, and reduces the number of small errors while it increases the number of large errors or blunders (Wiener and Curry, 1980; Wiener, 1988a). Field studies of crews transitioning to automatic cockpits show that the crews generally react favorably toward the new cockpits, but have strong reservations about the safety of such operations (Wiener and Curry, 1980; Wiener, 1988a).

The human factors profession is just beginning to look toward solutions to the problems brought by automation. Years of work would lie ahead even if the technology stood still, but cockpit technology continues to gallop ahead of the research necessary to understand and govern it.

It is equally unfortunate that the air and ground environments have been treated as separate entities. It hardly needs to be said that they are both inseparable parts of the same system,

and must be studied jointly. One of the problems encountered in operation of the modern ("glass cockpit") aircraft of the present generation (e.g., B-767/757 and A-310) is that the ATC system is not cordial to their modes of flight, and thus these aircraft cannot exploit the remarkable capabilities of the flight guidance systems.

These questions will be addressed by the project in Section 3.3, System Integration, and by project 11 on NAS/Cockpit Automation.

1.4.2 Flight Deck Certification

Another area badly lacking in human factors research is aircraft certification, which is a basic responsibility of the FAA, under Part 25 of the Federal Aviation Regulations (FARs). Part 25 makes little mention of human factors, except for calling for a workload analysis for the purpose of specifying the minimum crew.

Workload and other aspects of human factors (e.g., error analyses, the impact of automation on the crew's duties, etc.) need to be addressed at the certification stage. While much is known about the certification issues concerning structures, materials, aerodynamics, etc., there are many unanswered questions regarding human performance which, as we have seen, are implicated in a major proportion of aircraft accidents.

Section 3.4 of this plan, Certification and Regulatory Support, will address the human factors issues in certification:

- 13 - Cockpit Certification Criteria
- 14 - Aircrew Workload
- 15 - Human Factors Training for Certification Personnel

1.4.3 Warning and Alerting Systems

The new digital technologies have made possible far more sophisticated warning and alerting systems than were possible in traditional aircraft. The Electronic Instrument and Crew Alerting System (EICAS) of the new Boeing aircraft is an excellent example. Aircraft of the past suffered from an unrelenting, piecemeal addition of one alert after another, until the totality was quite unmanageable for the crew (Wiener and Curry, 1980).

Today, even more intelligent systems are possible, and at very little increase in hardware, cost, or weight. Researchers have called for systems that: understand the intent of the pilot and check for inconsistent inputs; forecast trouble before the system reaches an alarm point; enclose the plane and crew in a conceptual "electronic cocoon" and alert them when the protective cocoon is penetrated (Wiener and Curry, 1980). Advances in artificial intelligence technology offers even more possibilities (see Chambers and Nagel, 1985).

1.4.4 Operator Errors and Accident Analysis

The importance of operator errors can be seen from data already mentioned (Sears, 1986). Still there are great deficiencies in our knowledge of the mechanisms of human error, and little research under way to remedy this. The matter of human error takes on a new urgency if those who have studied automation (e.g., Wiener and Curry, 1980) are correct in their conclusion that the advancing technology has actually made it easier to commit large errors (blunders). For example, as automation has found its way into cockpits, the use of keyboards has increased, and these seem to be particularly prone to error (Aarons, 1988). The keyboard, as a primary means of input to a flight management computer, requires a multitude of keystrokes by the pilots, often at high workload phases of flight. A single keystroke may enter a potentially disastrous error, and what is worse, this error may go undetected for hours, as it may determine a down-course waypoint that does not become active for some time.

The challenge to technology is to find ways to manage, not necessarily eliminate, errors. Management may refer to error elimination, but may also include making systems error-tolerant, and error-evident. Error-tolerant refers to the fact that errors may be entered into the system, but the system may not have to act upon them, that is, the error may be trapped, and reported to the crew. For example, in the B-767/757 aircraft, the flight management computer (FMC) checks fuel load against origin, destination and forecast winds aloft. If the fuel load is insufficient, the crew is informed via a message on the Control-Display Unit (CDU).

Error-evident systems are those which make an erroneous input more apparent to the crew than less sophisticated systems. The Horizontal Situation Indicator (HSI) map mode on the 767/757 is an example. If an erroneous waypoint is entered, it will probably show up clearly as a large turn at the previous waypoint (Wiener, 1988a).

This document will establish the requirements for the first steps of inquiry into methods of error control and management, and will be a high priority item for FAA research. Furthermore, any practical results of this research in turn will contribute to the certification process. Since this is a flexible document, as research proceeds in the human error area, new projects dealing with advanced methods of error control can be added.

Work should also be encouraged on creation of an error data base. Some data are available from data-collection systems such as the Aviation Safety Reporting System (ASRS), and NASA field studies, but these depend on volitional self-reports and not on controlled observation. At this time, we simply do not have a database on error types and frequencies.

The basis for understanding human error and its control will be addressed in Section 3.5, Pilot Error and Capabilities, by the following abstracts:

- 16 - Accident/Incident Analysis
- 17 - In-Flight Data Collection
- 18 - Fatigue and Crew Interaction

1.4.5 Displays

Display design has been at the heart of human factors research and application from the beginning. A vast amount of information is available on the subject, and has been placed into handbooks and reviews. (See Stokes and Wickens, 1988, for a recent review.) By any standard, displays probably have been the best researched and best documented field of human factors, especially in the aviation environment.

If this is the case, why is continued research needed? The answer is that new technologies based on computer-generated displays now opens the field to many opportunities, and many problems.

Computer-generated displays allow the development of entirely new symbology, as exemplified by advanced systems such as Traffic Alert and Collision Avoidance System (TCAS), Head Up Displays (HUDs), HSI map modes, EICAS, etc. It was recognized early in the development of computer-generated displays that it would be foolish to use a computer graphics system to simply draw on a CRT the same analog symbology employed in "steam gauge" instruments. For example, the head-up display is not simply a repeat of the instrument panel, but an opportunity for an almost limitless variety of innovative symbology. TCAS, HUDs, and HSI map modes called upon designers to display information never before shown to the pilot. (For other examples of very creative displays, see Ellis, McGreevy, and Hitchcock, 1987.)

Computer-generated graphic displays now offer the crew what they have never had before, reconfigurable displays, which give the crew options over the information to display, and the display mode. This in itself is a great opportunity for the pilot to tailor his or her own display environment, and to change it as desired (e.g., one mode for climb, another for cruise). Modern systems allow the pilot to select or deselect information on the display (e.g., in a 767/757, the pilot can select by a switch whether to display emergency airports on the map). Again, it is essential that crew options be based on sound human factors research, not simply the availability of the means of doing it.

Thus, the area of aviation displays is now wide-open, and an entire new research effort must be mounted. Research questions involving complexity of displays, the use of color, the use of perspective, predictor and history displays, the problem of information overload, must be researched in order to give guidance to designers, and those who certify the new designs, as well as training departments. The technologies available for display design are so flexible that the designer is limited only by his or her own imagination. But, as with any new technology, there is a tendency to over-use computer graphics, to create a sea of symbols, to over-color, and perhaps overwhelm the operator. The human factors specialist will play an important role in the guidance of this activity.

Questions of aviation displays will be addressed in Section 3.2, Displays and Controls, in the following abstracts:

- 3 - Information Transfer (Flight Deck Information Requirements)
- 4 - Information Transfer (Display Design)

- 5 - Standardization of Flight Deck Displays, Controls, and Procedures
- 6 - Human Performance Criteria for Terminal Procedures
- 7 - Human Performance Criteria for Instrument Procedure Charts
- 8 - Weather Information Collection and Dissemination
- 9 - Rotorcraft Display and Control - IFR Requirements and Standards

1.4.6 Controls

Controls have been mentioned previously in several places. As in display design, computer-based control systems offer the designers great flexibility in design. Entire new technologies are available, and need to be examined carefully for their suitability for aviation. An excellent example is voice-input to computer systems, a rapidly expanding technology, but one that calls for a high degree of caution in its application.

The previous discussion of errors mentioned the problems of erroneous keyboard entry of data into flight management systems and other keyboard-based devices. This problem is so pervasive that it has its own nickname: "finger trouble." Some cockpits now have a variety of keyboards present, and they, in turn, have different layouts, as there is no aviation standard for keys and layouts. One carrier has in its 757 cockpit the control-display unit (CDU) keyboard by which data is entered into the FMC; immediately next to it is the ACARS keyboard which has a different layout.

Unfortunately, there is not presently a technology for replacing the keyboard as a means of entering alphanumeric data. Voice input is a possibility, as is a tracking device such as the "mouse" used in personal computer systems, but at this time the keyboard remains. The need for research into better control devices is obvious.

Questions of aircraft controls will be addressed in Section 3.2, Displays and Controls, in the following abstracts:

- 10 - Voice-Activated Systems
- 11 - Data Entry Devices and Human Error

1.4.7 Flight Crew Training

To date, most of the research in flight crew training has been concentrated in the military services. Airline and general aviation flight training has been based largely on experience, traditions, and regulatory requirements, and research is badly needed in the civil sector.

The regulation of all phases of pilot training, both in general aviation and in Part 121 and Part 135 operations, is the responsibility of the FAA. Over many years, the FARs and

appendices that govern pilot training have evolved; there is considerable sentiment that it is time for a fresh look at pilot training from top to bottom, with possible rewriting of the regulations. The technology that can contribute most to such a reconsideration is human factors.

In the airline industry, there are several concurrent trends that make such a re-examination critical:

- The pool of military trained pilots leaving the services, the traditional source of airline pilots, is shrinking, and therefore other sources of novice pilots must be developed. Many of new pilots will be trained *ab initio* by various schools, and they will enter airline service with lower flying time than the airlines have customarily demanded.
- The demand of the Part 121 carriers is expanding, and stripping the Part 135 (regional) carriers of their pilots. The regionals have also been a "farm club" for new pilots, and an excellent source of candidates for airline seats. The recent expansion of the Part 121 carriers has impacted severely on the regionals, who have reported that they have actually had to park airplanes due to a lack of pilots.
- The advanced cockpit technologies are moving down into smaller aircraft, flown by less experienced pilots. For example, the Saab 340, flown by many regional carriers, is an extremely advanced aircraft.
- All new airliners will carry only two pilots, and with the slow disappearance of the three-pilot models in the future, the training opportunity of the third seat is lost. Although the third seat was a mixed blessing, especially for well trained, former military pilots, it presently affords the opportunity for a low-time pilot to continue developing his/her cockpit sophistication and general airmanship training prior to occupying a pilot's seat.
- Due to the seniority system existing in the airlines today, it could easily come to pass that the junior aircraft of the fleet could be a very sophisticated model (e.g., MD-87 or A-320) and very inexperienced pilots could rapidly go through from *ab initio* training to the right seat of these aircraft. Here the novice pilot would encounter a highly sophisticated aircraft very early in his/her career. This is not necessarily bad -- we simply do not know the impact of placing a low-time pilot in such a position because it has not been happening. This is an urgent, researchable question.

Thus, the U.S. faces the greatest peacetime pilot training challenge in history. And it faces it with a lack of supporting human factors research. Airline pilot training has never been a highly popular area of research, but excellent work has been done in military training (Caro, 1988).

Some of these concerns will be addressed by the research abstracts in Section 3.6, Crew Training, including:

- 19 - Cockpit Resource Management/Line-Oriented Flight Training
- 20 - Training and Evaluation of Pilot Judgment
- 21 - Training Simulator Fidelity Criteria
- 22 - Simple Simulators
- 23 - Performance Feedback in Simulators
- 24 - Selection, Training and Certification of Airmen

Cockpit Human Factors Research Requirements

2.0 OVERVIEW

2.1 PROGRAM RATIONALE

This document is concerned with improving flight safety through the application of aviation human factors to the enhancement of flight crew performance. The safety, reliability, and efficiency of the National Airspace System depend on the men and women who operate and use it. Aviation human factors is the study of how these people function in the performance of their jobs as controllers, pilots, or maintenance and ground support personnel, and of how the system interfaces can be changed to improve that performance.

Modern aviation technology has improved the reliability and efficiency of new aviation equipment, and the complexity of aviation systems have had to increase to accommodate larger numbers of users under a greater and more demanding variety of flight conditions. In the midst of these changes, the human operator remains largely unchanged and his limits and capabilities are increasingly recognized as an important factor in the design of flight systems. Aviation safety areas which have been the subject of recent attention include both the air traffic control and the cockpit aspects of the system. Computer failures and near mid-air collisions brought increased attention to air traffic control, and flight deck modernization and the crew complement issue has brought attention to cockpit issues.

In the past, the development and application of new aviation system technology in both ATC and flight systems has been directed primarily toward increasing the traffic capacity of the NAS. With a few notable exceptions, such as the Traffic Alert and Collision Avoidance System (TCAS) and the Ground Proximity Warning System (GPWS), advances in technology have not been applied directly toward the improvement of flight safety. The research and development requirements specified in this document are intended to develop and apply behavioral technology primarily towards the improvement of flight safety.

A coordinated and systematic approach to improving flight crew performance is far from being fully developed. This document is being maintained to facilitate that development by focusing on cockpit-related problems and to provide a single source for cockpit-related human factors research requirements. Research conducted in support of these requirements will:

- Promote the advancement of cockpit technology and flight systems through the development and application of methods for measuring and understanding the pilot's capabilities for assimilating information from advanced display systems and for using and monitoring automated flight control systems;

- Increase flight safety through the identification and mitigation of conditions that promote pilot error; and
- Develop increased awareness within the aviation community of the role of human factors issues in flight safety.

2.2 OBJECTIVES OF THIS DOCUMENT

This document will contribute to the development of human factors knowledge and techniques in a variety of ways. It will:

- Outline what is needed to advance the science of human factors knowledge and its application in design and manufacturing, regulation and certification, training, and flight operations.
- Outline the participation of the FAA in advancing research in aviation human factors.
- Continue to reflect contemporary human factors concerns of the aviation community as a living document.

The research, engineering and development (RE&D) projects established to meet these requirements will:

- Advance the current and projected status of aviation human factors in the U.S. primarily in aviation, but also in other fields that traditionally look to aviation for technological leadership.
- Advance our understanding of the human factors impact of automation technology.
- Aid the FAA in the development of standards and requirements for operational procedures, pilot training, and certification.

2.3 PROGRAM OPERATIONS

REQUIREMENTS IDENTIFICATION: The research efforts included in this plan are generated by the various offices within FAA, based upon a continuous review of FAA responsibilities. The identification of cockpit related human performance issues that help to define these responsibilities are continually solicited from the aviation community through both formal and informal means. The identification and definition of research requirements will continue to involve a wide-ranging aviation constituency, including government personnel, manufacturers, carrier operators, manufacturers, trade organizations, researchers and other special interest groups. In the future, problems requiring research attention will be identified through special seminars, meetings of various technical societies, and through internal FAA sources.

TECHNICAL APPROACH: The approach selected to address the requirement for research depends in part upon work currently underway in the research community and the resources available to support the work. The approaches selected will be chosen to optimize the use of available funds, staff, fixed facilities and other resources in order to address the greatest number of high priority items in the near term. To the greatest extent possible, this program will take advantage of current research within the Department of Transportation (DOT), the Department of Defense (DOD), and NASA. Where possible, cooperative research efforts with other government agencies will be promoted in order to take advantage of existing expertise and facilities. Cooperative research agreements should be pursued with the aviation industry to tap their intimate knowledge of commercial operations, their access to professional flight personnel, their training facilities, and their data gathering capabilities. The approaches will also be selected to take advantage of the technical expertise and the operational experience of the various aviation professional and trade organizations. The resulting research will be conducted by the FAA, TSC, DOD, NASA, industry, and university laboratories, as appropriate.

RESEARCH APPLICATIONS: The results of most of the research and development efforts will be used in the development of advisories, guidelines, and regulations to support the FAA's promotional and regulatory responsibilities. A limited number of carefully selected research efforts will be conducted to support and promote the technical and informational requirements of aviation interests outside of the agency.

2.4 PROGRAM DESCRIPTION

These FAA cockpit human factors research requirements address seven areas of contemporary concern in cockpit technology that have a direct bearing on flight crew performance:

- **Aircraft Automation;**
Includes issues related to the influence of flight deck automation on flight crew capability.
- **Causal factors in accidents and incidents;**
Includes the development and maintenance of a program dedicated to classifying pilot errors and identifying the causes of these errors.
- **Human performance assessment and improvement;**
Includes issues related to aircrew workload and the effects of fatigue on crew performance.
- **Information transfer and management;**
Includes the identification of the information required by flight crews and the development of guidelines for the transfer and management of that information.

- **Control and display technology;**
Includes issues concerned with information transfer, and the design and evaluation of flight deck displays and controls.
- **Flight crew certification and training;**
Includes increasing the effectiveness of flight crew training and determining the minimum level of simulator fidelity required to achieve training objectives.
- **Flight deck certification criteria;**
Includes the development of systematic and quantifiable procedures for certifying advanced technology cockpits.

Research is required in these areas because of the lack of adequate knowledge about flight crew performance and its interactions with advanced cockpit systems to:

- Support and promote the advancement of new cockpit technology;
- Identify the underlying causes of pilot error;
- Support the development of standards for flight crew training that are based on pilot performance; and
- Support the development of procedures for the certification of cockpit equipment that are based on pilot performance.

Cockpit Human Factors Research Requirements

3.0 RESEARCH REQUIREMENTS

This section of the plan includes descriptions of the 24 human factors research requirements. The project descriptions are divided among the following programmatic areas of work:

- Cockpit Automation;
- Displays and Controls;
- System Integration;
- Certification and regulatory support;
- Pilot error and capabilities; and
- Crew training.

Some requirements could be included in any one of a number of the seven areas, particularly since a large number of them are related to automation, displays, and have regulatory implications. Where categorization overlap was present, we tried to identify the main focus of the human factors issue, determine its relation to other problem areas and then assign it to an area that included related work. This was done to promote an integrated approach to the work.

Each abstract includes a brief discussion of the problem area, a statement of need or requirement for work, a proposed approach to that work, and a list of products that are expected from the work. The abstract number indicates the order in which the resume appears in this document and is not intended to imply a level of research priority. An abbreviated description of the proposed work is provided in the body of the abstract. Where information could be obtained about related work that is underway, the purpose, focus, and status of that work is provided in the REMARKS section.

1. The first part of the document discusses the importance of maintaining accurate records of all transactions and activities. It emphasizes the need for transparency and accountability in financial reporting.

2. The second part of the document outlines the various methods and techniques used to collect and analyze data. It includes a detailed description of the experimental procedures and the tools used for data collection.

3. The third part of the document presents the results of the study, including a comparison of the different methods and techniques used. It discusses the strengths and weaknesses of each approach and provides a summary of the findings.

4. The fourth part of the document discusses the implications of the study and provides recommendations for future research. It highlights the need for further investigation into the effectiveness of the different methods and techniques used.

5. The fifth part of the document concludes the study and provides a final summary of the findings. It reiterates the importance of maintaining accurate records and the need for transparency and accountability in financial reporting.

6. The sixth part of the document discusses the limitations of the study and provides a list of references. It acknowledges the potential biases and limitations of the data and methods used and provides a list of sources used in the study.

7. The seventh part of the document provides a detailed description of the experimental procedures and the tools used for data collection. It includes a list of the equipment and materials used and a description of the experimental setup.

8. The eighth part of the document presents the results of the study, including a comparison of the different methods and techniques used. It discusses the strengths and weaknesses of each approach and provides a summary of the findings.

9. The ninth part of the document discusses the implications of the study and provides recommendations for future research. It highlights the need for further investigation into the effectiveness of the different methods and techniques used.

10. The tenth part of the document concludes the study and provides a final summary of the findings. It reiterates the importance of maintaining accurate records and the need for transparency and accountability in financial reporting.

11. The eleventh part of the document provides a list of references and a detailed description of the experimental procedures and the tools used for data collection. It includes a list of the equipment and materials used and a description of the experimental setup.

12. The twelfth part of the document discusses the limitations of the study and provides a list of references. It acknowledges the potential biases and limitations of the data and methods used and provides a list of sources used in the study.

13. The thirteenth part of the document provides a detailed description of the experimental procedures and the tools used for data collection. It includes a list of the equipment and materials used and a description of the experimental setup.

14. The fourteenth part of the document presents the results of the study, including a comparison of the different methods and techniques used. It discusses the strengths and weaknesses of each approach and provides a summary of the findings.

15. The fifteenth part of the document discusses the implications of the study and provides recommendations for future research. It highlights the need for further investigation into the effectiveness of the different methods and techniques used.

16. The sixteenth part of the document concludes the study and provides a final summary of the findings. It reiterates the importance of maintaining accurate records and the need for transparency and accountability in financial reporting.

17. The seventeenth part of the document discusses the limitations of the study and provides a list of references. It acknowledges the potential biases and limitations of the data and methods used and provides a list of sources used in the study.

18. The eighteenth part of the document provides a detailed description of the experimental procedures and the tools used for data collection. It includes a list of the equipment and materials used and a description of the experimental setup.

19. The nineteenth part of the document presents the results of the study, including a comparison of the different methods and techniques used. It discusses the strengths and weaknesses of each approach and provides a summary of the findings.

20. The twentieth part of the document discusses the implications of the study and provides recommendations for future research. It highlights the need for further investigation into the effectiveness of the different methods and techniques used.

21. The twenty-first part of the document concludes the study and provides a final summary of the findings. It reiterates the importance of maintaining accurate records and the need for transparency and accountability in financial reporting.

22. The twenty-second part of the document provides a list of references and a detailed description of the experimental procedures and the tools used for data collection. It includes a list of the equipment and materials used and a description of the experimental setup.

23. The twenty-third part of the document discusses the limitations of the study and provides a list of references. It acknowledges the potential biases and limitations of the data and methods used and provides a list of sources used in the study.

24. The twenty-fourth part of the document provides a detailed description of the experimental procedures and the tools used for data collection. It includes a list of the equipment and materials used and a description of the experimental setup.

25. The twenty-fifth part of the document presents the results of the study, including a comparison of the different methods and techniques used. It discusses the strengths and weaknesses of each approach and provides a summary of the findings.

3.1 Cockpit Automation

DATE: 1/15/85

ABSTRACT: 1

DATE OF REVISION: 1/15/88

OFFICES OF PRIMARY INTEREST: AIR-100, ANM-100, ACE-100, ASW-100.

PROJECT TITLE: Pilot Intervention and Control (Manual Reversion)

OBJECTIVE: Determine whether cockpit flight data information systems provide sufficient information for flight crews to detect the need to intervene in the automated control of aircraft and to fly them manually if required.

REQUIREMENT: System automation without the ability for adequate crew monitoring and reversion to manual flight when required was identified as one of the greatest concerns of a panel of airline pilots (ALPA) during the November 1980 DOT/FAA Human Factors Workshop on Aviation, Cambridge, MA. Examples of the reason for such concerns include inadequate situation information of flight critical systems (e.g., EICAS) and envelope protection that cannot be disconnected.

APPROACH: Identify information and procedures required to ensure full awareness by flight crews of the status of flight deck systems and controls.

Identify information that should be provided to flight crews to safely operate aircraft with degraded automated systems.

Determine the options that should be provided to flight crews to intervene in system automation and to manually control aircraft with degraded automated systems.

RESULTS: Checklists and guidelines to assist certification personnel in assessing flight deck systems with regard to the information and control capabilities that they provided to flight crews.

Advisory circulars identifying the information and control requirements of flight crews with regard to automation degradation.

REMARKS:

DATE: 1/15/85

ABSTRACT: 2

DATE OF REVISION: 12/30/87

OFFICES OF PRIMARY INTEREST: AFS-200

PROJECT TITLE: Pilot Proficiency and Automated Systems

OBJECTIVE: Determine the extent to which the use of automated systems may degrade a pilot's ability to fly manually. Determine the training necessary to ensure maintenance of manual skills required in the event of failure of automated flight systems.

REQUIREMENT: The extensive use of automated systems during flight has caused concern about the possible loss of manual piloting skills through disuse that may be required in the event of automation failure. If the use of automated systems results in such loss, special actions must be taken to facilitate retention of manual flight skills by flight crews of highly automated aircraft.

APPROACH: Survey pilots and flight training professionals in order to determine the extent of the problem.

Survey air carrier training and checking practices, and operational procedures that affect manual proficiency.

Analyze relevant data included in aviation safety data bases.

Empirically determine decay rates resulting from disuse of critical flight skills.

Identify and evaluate methods of preventing degradation of manual proficiency (e.g., embedded training).

RESULTS: Report on the effects of current training and checking practices and operational procedures in automated aircraft on pilots' manual flying skills.

Reports on evaluations of various procedural and training methods of preventing degradation of manual proficiency.

REMARKS: Air carrier training personnel report flight crews of high tech aircraft require more training in simulators during recurrent training to restore their proficiency level to manual flight standards. There exists no data on the rates of decay of flight skills following recurrent training.

1. The first part of the document discusses the importance of maintaining accurate records of all transactions and activities.

2. It then outlines the various methods used to collect and analyze data, including surveys, interviews, and focus groups.

3. The next section describes the results of the data collection process, highlighting key findings and trends.

4. Finally, the document concludes with a summary of the overall findings and recommendations for future research.

5. The document is organized into several sections, each focusing on a different aspect of the research process.

6. The first section provides an overview of the research objectives and the scope of the study.

7. The second section details the methodology used to collect and analyze the data, including a description of the sample and the data collection instruments.

8. The third section presents the results of the data analysis, including a discussion of the key findings and their implications.

9. The fourth section discusses the limitations of the study and provides recommendations for future research.

10. The final section provides a summary of the overall findings and conclusions of the study.

11. The document is written in a clear and concise style, using simple language and avoiding technical jargon.

12. The document is well-organized and easy to read, with a clear flow of information from the introduction to the conclusion.

13. The document is a valuable resource for anyone interested in the field of research and data analysis.

14. The document provides a comprehensive overview of the research process, from the initial planning to the final analysis and reporting.

15. The document is a must-read for anyone who wants to learn more about how to conduct research and analyze data effectively.

16. The document is a great starting point for anyone who is new to the field of research and data analysis.

17. The document provides a clear and concise overview of the research process, making it easy to understand and follow.

18. The document is a valuable resource for anyone who wants to improve their research and data analysis skills.

19. The document is a great resource for anyone who is looking for a comprehensive overview of the research process.

20. The document is a must-read for anyone who is interested in the field of research and data analysis.

3.2 Displays and Controls

DATE: 1/15/85

ABSTRACT: 3

DATE OF REVISION: 1/15/88

OFFICES OF PRIMARY INTEREST: AFS-200, ACE-100, ASW-100, AIR-100, ANM-100

PROJECT TITLE: Information Transfer (Flight Deck Information Requirements)

OBJECTIVE: Identify the information required by flight crews to fly commercial air carriers safely in the evolving NAS.

REQUIREMENT: The information required by crews on the flight deck and by individual crewmembers is changing rapidly as the size of crews is decreased, and as aircraft complexity and automation introduce new monitoring requirements.

With the introduction of new data link systems, and advances in information presentation technology present in the new glass cockpits, it is easy to overload flight crews with more information than they can handle and still neglect to provide them with the information they need when they need it. Flight deck designers need specific requirements for the information that must be provided to flightcrews.

APPROACH: Identify tasks that must be accomplished by flight crews in advanced technology aircraft; determine minimum information required by each crew member to accomplish these tasks, provide necessary back up to other crew members, and provide the information redundancy necessary for status verification.

Test information requirement assumptions using representative flight scenarios in a full mission simulator, and validate results.

Develop and apply a method for the dynamic allocation of flight deck tasks to crew members and to automated systems, and recommend assignments as a function of operational requirements and aircraft status.

RESULTS: Method and evaluation criteria for determining flight crew information requirements.

Lists of information requirements that are aircraft-specific for use in certification of cockpit information systems.

Inventory of information required in the cockpits of generic aircraft to operate in the NAS and situations and conditions under which that information is needed.

Continued on next page

DATE: 1/15/85

ABSTRACT: 3

DATE OF REVISION: 1/15/88

OFFICES OF PRIMARY INTEREST: AFS-200, ACE-100, ASW-100, AIR-100-ANM-100

PROJECT TITLE: Information Transfer (Flight Deck Information Requirements)

Continued

REMARKS:

A FAA project to identify, classify and prioritize flight deck information is currently planned.

This area is specified in ATA's National Human Performance Plan to Enhance Aviation Safety as a high priority research item.

DATE: 12/8/87

ABSTRACT: 4

DATE OF REVISION: 1/15/88

OFFICES OF PRIMARY INTEREST: AIR-100, ACE-100, ASW-100, ANM-100

PROJECT TITLE: Information Transfer (Display Design)

OBJECTIVE: | Develop guidelines for designing and criteria for evaluating cockpit displays regarding their efficiency of use by flightcrews.

REQUIREMENT: | The information that can be presented to flight crews is no longer limited by the fixed format of electromechanical displays. New advances in display technology make it possible to present more information to the crew than they can assimilate, and such presentations can be made with an almost infinite variety of formats using visual, tactual, and auditory techniques. Additionally, increased monitoring responsibilities associated with automation and data link utilization have increased the information that flightcrews must process in any given flight.

Faced with these requirements, cockpit designers need specifications of information requirements, guidelines for display design, and human factors criteria with which to evaluate cockpit layouts and to select optimum designs from a variety of design options.

APPROACH: | Develop generic checklists of design considerations to be used in the evaluation and certification of cockpit displays, particularly those that combine and integrate information currently presented on separate displays.

Develop objective and quantitative measures for crew performance for use in the evaluation and certification of cockpit displays. Measures should permit assessment of: the efficiency of transmission of information to the flight crew; the potential for, and operational importance of, errors that can be made with the displays; the contribution of displayed information to situational awareness; and the potential of the display for overloading crews with information.

Develop a standard set of flight scenarios to be used in simulation and flight evaluations of new or modified displays.

Continued on next page

DATE: 12/8/87

ABSTRACT: 4

DATE OF REVISION: 1/15/88

OFFICES OF PRIMARY INTEREST: AIR-100, ACE-100, ASW-100, ANM-100

PROJECT TITLE: Information Transfer (Display Design)

Continued

- APPROACH:** | Examples of specific problem areas to be addressed include:
- Display of weather information
 - Display of MLS course and annunciator data
 - Display of TCAS traffic data and advisory information
 - Evaluation of HUD and Fail Passive Autoland as a hybrid system with the pilot in the active control loop.
- RESULTS:** | Guidelines for the human factors evaluation of cockpit displays.
- REMARKS:** | The development of certification procedures that ensure proper evaluation of the human engineering aspects of display designs is a high priority item in ATA's aviation plan for human performance research.

DATE: 10/20/88

ABSTRACT: 5

DATE OF REVISION: 12/30/87

OFFICES OF PRIMARY INTEREST: AFS-200, AIR-100, ANM-100, ACE-100, ASW-100

PROJECT TITLE: Standardization of Flight Deck Displays, Controls, and Procedures

OBJECTIVE: Determine the advantages and disadvantages of standardizing cockpit displays, controls, and procedures.

REQUIREMENTS: Prior to deregulation, display and control designs and cockpit layouts were relatively standard within individual companies. The Federal Aviation Regulations permitted companies to specify cockpit layouts according to their own preferences, providing that they met basic Part 25 certification and Part 121 operating requirements. In addition, advances in cockpit technology are providing designers with increasing capability for changing the appearance and information content of displays and the feel location and function of cockpit controls.

Airline mergers with their associated mixing of fleets, and the increasing flexibility in cockpit design are producing a proliferation of variations in cockpit design and procedures within individual fleets. Differences training may provide pilots with the ability necessary to fly any single cockpit skillfully and with the abilities necessary to fly any single cockpit skillfully and safely. However, requiring pilots to switch among aircraft of a single type with different cockpit displays and controls increases the chances of pilot error.

APPROACH: Determine the influence of variations in cockpit design and procedures on the potential for pilot error.

Determine the advantages, disadvantages, and desirable areas and limits for standardizing cockpit designs and procedures.

RESULTS: Design guidelines and certification criteria.

Improved training and operational procedures.

RELATED WORK: AC 25-11, "Transport Category Airplanes Electronic Display Systems" dated July 16, 1987.

SAE standards.

DATE: 1/15/85

ABSTRACT: 6

DATE OF REVISION: 12/30/87

OFFICES OF PRIMARY INTEREST: AFS-200, ATR-100, AT0-200, AVN-200

PROJECT TITLE: Human Performance Criteria for Terminal Procedures

OBJECTIVE:

Establish human performance checklists for use by procedure specialists and flight inspection pilots in the development of instrument approach procedures, SIDs (Standard Instrument Departure Procedures), noise abatement procedures, and STAR's (Standard Terminal Arrival Routes) that would improve the speed and accuracy of information transfer.

REQUIREMENT:

NTSB investigations of nine serious accidents led to recommendations to modify specific approach procedures and approach charts. NTSB Recommendations A-81-91 and 92 state that "an attack on the aggregate problem by alleviating individual approach procedure problems on a post-accident basis is not satisfactory." The Board specified that "a better, more efficient method would be to incorporate human factors design considerations into the development, design, and evaluation of all approach procedures and approach charts before accidents occur."

APPROACH:

Survey users in order to identify current problems with terminal procedures.

Review problems associated with present IFR charts and VFR charts.

Develop and validate workload and risk assessment procedures and criteria.

Apply the pilot performance methods and criteria to the redesign of selected terminal procedures.

RESULTS:

Pilot performance checklists for use in the design and evaluation of terminal procedures.

Improved IFR procedures.

REMARKS:

DATE: 1/15/85

ABSTRACT: 7

DATE OF REVISION: 1/5/88

OFFICES OF PRIMARY INTEREST: AFS-200, AVN-200, ATO-200, ATR-100

PROJECT TITLE: Human Performance Criteria for Instrument Procedure Charts

OBJECTIVES: | Improve the design of instrument procedure charts to facilitate the speed and accuracy of the transfer of information to flight crews.

REQUIREMENT: | The Special Air Safety Advisory Group (SASAG), commissioned by the FAA in 1976 to study the air transport system and make recommendations on how to improve air safety criticized the design of approach charts. Their report stated that the charts were too complicated, cluttered, impractical, hard to read, and did not contain all of the important information.

The Report of the President's Task Force on Aircraft Crew Complement stated that "enroute, terminal area, and approach charts are frequently designed in a way that makes them difficult to use. The design and contents of these charts should be improved."

APPROACH: | Survey users in order to identify problems with current chart designs.

Analyze problems to determine how they may be corrected through chart redesign.

Analyze information content of current charts to determine which of pilots information requirements are not met.

Analyze chart design and formatting to determine what must be changed to improve in-flight readability.

Develop design criteria and evaluation methods based on pilot performance.

Design and evaluate prototype charts.

RESULTS: | Validated design guidelines for approach charts.

Methods and behavioral criteria for evaluating new chart designs.

Continued on next page

DATE: 1/15/85

ABSTRACT: 7

DATE OF REVISION: 1/5/88

OFFICES OF PRIMARY INTEREST: AFS-200, AVN-200, ATO-200, ATR-100

PROJECT TITLE: Human Performance Criteria for Instrument Procedure Charts

Continued

REMARKS:

Mail survey of pilot concerns and preferences about the design of current approach plates was completed. DOT/FAA/PM-87/15, May 1987.

SAE sub-committee on charting has been formed and will identify safety issues associated with approach plates and procedures.

DATE: 1/15/85

ABSTRACT: 8

DATE OF REVISION: 12/30/87

OFFICES OF PRIMARY INTEREST: AFS-200, AIR-100, ASA-100

PROJECT TITLE: Weather Information Collection and Dissemination

OBJECTIVE: Identify weather information requirements of pilots, and increase the efficiency with which this information is delivered to the flight crew.

REQUIREMENT: For safe flight, pilots require accurate and relevant weather information which is disseminated in a timely and efficient manner. The most immediate and relevant of such information is that reported by other pilots. Many PIREPS reported to enroute, approach, and departure controllers at central facilities do not get passed on to other pilots.

Furthermore, the weather information that is delivered to the flight deck must be formatted to maximize the ease with which it can be read, understood, and related to in-flight requirements. Both the informational and operational needs of pilots must be considered in determining the exact format, depth, and availability of weather information to the crew.

APPROACH: Survey pilots and companies to identify weather information that is being provided flight crews and to identify weather information requirements that are not currently being met.

Establish procedures for determination, review, and approval of weather information to be provided flight crews by the NAS.

Improve ATC assistance to pilots who are confronted with uncertain weather conditions.

Improve packaging of weather information to assist pilots in-flight decision-making.

Continued on next page

DATE: 1/15/85

ABSTRACT: 8

DATE OF REVISION: 12/30/87

OFFICES OF PRIMARY INTEREST: AFS-200, AIR-100, ASA-100

PROJECT TITLE: Weather Information Collection and Dissemination

Continued

RESULTS:

Specification of weather information needed by pilots.

Requirements for the dissemination of weather information to be included in the NAS Operational Requirements Document.

Guidelines and procedures for ATC assistance to pilots regarding weather advisories.

Improved formats used to present weather information to flight crews

REMARKS:

Survey of flight crews' weather requirements and the sources and content of the weather information currently provided to dispatch and flight crews has been completed by TSC and is currently under review at FAA.

Considerable work on the collection and assessment of weather information is being sponsored by the FAA, particularly on windshear.

DATE: 1/15/85

ABSTRACT: 9

DATE OF REVISION: 2/18/88

OFFICES OF PRIMARY INTEREST: ASF-200, AIR-100, ASW-100

PROJECT TITLE: Rotorcraft Display and Control - IFR Requirements and Standards

OBJECTIVES: | Develop criteria that are based on flight crew performance for evaluating new cockpit displays, controls, and procedures designed to reduce pilot workload in IMC.

REQUIREMENT: | NTSB Safety Recommendation A-78-23, states that the FAA should "expand its proposed research plans on 'Cockpit Human Factors Problems', particularly in the area of Human Capabilities and Limitations and Displays and Controls, to include problems peculiar to helicopter controls and displays."

At the FAA's Third Human Factors Workshop on Aviation, held in Cambridge, MA., March 1981, representatives from the helicopter manufacturers and the Helicopter Association International, identified the need for the development of data to permit the consideration of human factors issues in the certification and standardization of new displays and controls.

APPROACH: | To be determined.

RESULTS: | Certification guidelines

REMARKS: | Conference was held (Phoenix, 1987) to identify certification issues critical to low visibility flight conditions.

A Sikorsky S76 helicopter has been equipped with an electronic flight instrument system and instrumented for research by the Agency on display and control issues.

DATE: 1/15/85

ABSTRACT: 10

DATE OF REVISION: 1/15/88

OFFICES OF PRIMARY INTEREST: AIR-100, ASW-100, ANM-100, ACE-100

PROJECT TITLE: Voice-Activated Systems

OBJECTIVE: | Develop guidelines for the use of voice-activated flight management systems in aircraft cockpits; develop system performance criteria for certification.

REQUIREMENT: | Advances in flight control are increasing the pilot's system management responsibilities and need for information. In some cases, physical involvement with the aircraft increases because the pilot functions as a back-up component of closely coupled semi-automated systems. A pilot working with such systems during high workload phases of flight may not be able to afford the head down time or have the spare hand required to operate, for example, the radio controls. This may be particularly so in helicopter operations.

In anticipation of such performance requirements, some manufacturers are exploring voice-activated systems as a means of extending the pilots ability to control the aircraft under high workload conditions.

To assure the safe use of this technology in aviation, and support its efficient development by industry, the FAA must be able to recognize and certify safe systems when they appear.

APPROACH: | Survey the state-of-the-art of cockpit voice control technology.

Initiate a cooperative inter-agency agreement with the USAF to test and evaluate prototype voice-activated cockpit control systems.

Develop guidelines for the application of voice control systems to cockpit requirements.

RESULTS: | Report of the status of voice control technology.

Interagency agreement between DOD and FAA to facilitate the change of information on voice technology.

Evaluation and application guidelines.

DATE: 1/15/85

ABSTRACT: 11

DATE OF REVISION: 2/18/88

OFFICES OF PRIMARY INTEREST: AFS-100, AIR-100, ANM-100, ACE-100, ASW-100

PROJECT TITLE: Data Entry Devices and Human Error

OBJECTIVE: | Develop equipment standards and operational procedures for use with digital data-input devices to minimize pilot error. Develop requirements for training flight crews in the use of these devices.

REQUIREMENT: | Data entry errors can occur during initial programming and reprogramming of inertial navigation and other flight management systems that require manual programming.

APPROACH: | Survey and evaluate data entry devices for possible flight deck applications. Identify operational conditions and equipment design characteristics that influence data entry errors.

Survey flight crews and available data bases (e.g., ASRS) to identify types, frequencies and operational significance of data entry errors that are made on the flight deck.

Conduct laboratory and simulator studies to verify and quantify the influence of selected operational conditions and equipment design features that influence data entry errors.

Develop and test procedural and design guidelines for minimizing data entry errors.

RESULTS: | Guidelines for the human factors evaluation of data entry devices.

Training guidelines for the use of digital data input devices.

Guidelines for procedures to be used for entering data and for validation of data entries.

REMARKS: | Current work in this area includes an examination of pilot error with LORAN-C receivers.

3.3 System Integration

DATE: 1/15/85

ABSTRACT: 12

DATE OF REVISION: 1/15/88

OFFICES OF PRIMARY INTEREST: AFS-200, AIR-100, ANM-100, ASW-100,
ACE-100, ATO-300, ATR-100

PROJECT TITLE: NAS/Cockpit Automation

OBJECTIVE: | Develop intra-agency design review requirements and evaluation methods to ensure that the modernization of the NAS and related changes in the cockpit do not influence pilot workload to the detriment of flight safety.

REQUIREMENT: | Planning and analytical efforts as currently practiced in designing automation for the National Airspace System do not consider the impact of this automation on cockpit design or pilot workload. Cockpit automation and advanced information transfer technologies have an increasing potential for overloading flight crews particularly during critical phases of flight. In the absence of intra-organization coordination during the development of procedures and concepts for NAS modernization, and the systematic assessment of the results of modernization efforts on cockpit design and activities, flight crew performance could be threatened through information overload.

APPROACH: | Draft intra-agency coordination requirements for review and evaluation of proposed changes in the NAS which may require changes in-flight crew activities.

Develop, test, and refine cooperative test and evaluation methods and facilities for testing ATC-cockpit systems.

RESULTS: | Intra-agency review and evaluation procedures.

Requirements for a test and evaluation capability.

STATUS: | Workshop on Cockpit Automation at NASA-Ames, August 1988.

REMARKS: |

3.4 Certification and Regulatory Support

DATE: 1/15/85

ABSTRACT: 13

DATE OF REVISION: 11/25/87

OFFICES OF PRIMARY INTEREST: AIR-100, ANM-100, ACE-100, ASW-100

PROJECT TITLE: Cockpit Certification Criteria

OBJECTIVE: | Develop certification criteria for advanced technology cockpits, that are based upon objective measures of crew performance.

REQUIREMENT: | Current flight deck certification decisions are based upon the subjective assessment of FAA test pilots. No quantitative performance standards are available to objectify certification test results, either in terms of pilot effort required to fly with the new equipment or the level of crew performance. In the absence of standard and objective criteria, there is little information available from which manufacturers can develop design guidelines that they are confident will result in certifiable products. This problem is particularly acute for new designs that are very different from the equipment that they are proposed to replace.

APPROACH: | Document current practices used in the certification of flight deck systems; identify advantages and limitations of current practices.

Design and conduct a research program to develop criteria, standard measures, and procedures for use in evaluating entire cockpit configurations. Accurate information transfer, situational awareness, and workload will be among the conditions to be assessed. The usefulness of standard flight test scenarios will also be examined.

Design and evaluate methods for assessing the error tolerance of flight deck systems.

RESULTS: | Behavioral criteria and procedures for evaluating entire cockpit configurations, including the degree to which the designs promote:

- Situational awareness
- Satisfactory workload profiles
- Efficient information transfer.

REMARKS: |

DATE: 1/15/8

ABSTRACT: 14

DATE OF REVISION: 11/25/87

OFFICES OF PRIMARY INTEREST: AIR-100, ANM-100, ACE-100, ASW-100

PROJECT TITLE: Aircrew Workload

OBJECTIVE: Determine what ranges of aircrew workload are consistent with acceptable levels of performance and develop strategies for coping with workload extremes.

REQUIREMENT: Extensive research has been conducted in search of valid and reliable measures of pilot workload. While some progress has been made in developing useful measures, many unanswered questions remain - particularly in the areas of cognitive workload and the ways in which pilots successfully cope with workload extremes. These issues have important implications for the design, certification, and operation of current and future aircraft.

APPROACH: Identify the symptoms of levels of physical and cognitive workload that are unacceptable.

Identify the range of acceptable levels of workload and the optimal level of workload.

Develop procedures for assessing workload during the certification process.

Develop methods of improving pilots' abilities to cope with workload extremes.

RESULTS: Quantitative procedures for assessing workload during certification.

Identification of acceptable levels of physical and cognitive workload.

Strategies for coping with workload extremes.

REMARKS: Much of this work is being conducted at NASA - Ames.

DATE: 9/21/88

ABSTRACT: 15

DATE OF REVISION:

OFFICES OF PRIMARY INTEREST: AFS-200, AIR-100, ANM-100, ACE-100, ASW-100

PROJECT TITLE: Human Factors Training for Certification Personnel

OBJECTIVE: | To develop a course of instruction for selected FAA personnel on the measurement of human performance, the limits and capabilities of the human operator, and the potential application of this information to aircraft certification.

REQUIREMENT: | ASRS-reports, pilot testimony, and NTSB accident reports indicate that in-flight errors in the operation of modern aircraft have often been induced by the design and operation of flight deck systems. Following examination of the prominence and nature of pilot errors in aircraft accidents and incidents, human factors professionals, pilots and aviation safety officials have recommended that the FAA develop expertise in human factors. Accident statistics indicate that the minority of aircraft accidents are the result of mechanical causes, whereas the majority involve operator error. FAA personnel responsible for certifying the safety of aircraft systems often come to the task with solid engineering backgrounds but little if any formal training in human factors. Certification standards and methods regarding human factors issues lag far behind the engineering aspects of aircraft. A cadre of certification personnel trained in human factors is a fundamental step toward decreasing pilot error as a causal factor in aircraft accidents.

APPROACH: | Develop and administer a course specifically tailored to educating FAA certification personnel about the relevant human capabilities and limits, and the measurement of these functions relevant to flight safety and certification.

RESULTS: | A human factors course for selected FAA certification personnel.

REMARKS: |

3.5 Pilot Error and Capabilities

DATE: 1/15/85

ABSTRACT: 16

DATE OF REVISION: 12/30/87

OFFICES OF PRIMARY INTEREST: AFS-200, AIR-100

PROJECT TITLE: Causal factors in Accidents and Incidents

OBJECTIVE: | Develop, coordinate, and maintain a program dedicated to identifying the causes of pilot error.

REQUIREMENT: | Pilot error continues to be the primary cause of aviation accidents. Existing accident and incident data do not reveal the behavioral patterns which lead to a resulting accident or incident. Innovative techniques must be identified and employed in order to define these patterns in decision-making and to recommend preventive measures. This investigation must also include consideration of contributing factors, such as: equipment design, operational procedures, and environmental factors.

APPROACH: | In cooperation with other government agencies, identify existing data bases and hard-copy data that will provide information on the flight systems and flight crew characteristics that contribute to pilot error. Include consideration of ASRS "Callback" data to identify system design and pilot error safety issues.

Identify accident types of special interest and formulate questions to be answered through the analysis of available data.

Conduct analysis of pertinent data to be included in either a central data base (to be created by merging selected data from several existing accident data bases) or separate and independent data bases.

Gather additional data by conducting interviews with pilots who have survived accidents in order to identify human factors issues that may have contributed to the cause of the accident.

Develop a typology of flight crew errors, and a model of pilot error that is based on pilot performance and can be used to identify the circumstances under which flight crew errors are likely to occur.

Develop and evaluate error reduction techniques.

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DATE: 1/15/85

ABSTRACT: 16

DATE OF REVISION: 12/30/87

OFFICES OF PRIMARY INTEREST: AFS-200, AIR-100

PROJECT TITLE: Causal Factors in Accidents and Incidents

Continued

RESULTS:

A central data base or group of data bases that contain information that can answer questions regarding accident types of special interest.

Identification of human factors issues that contributed to the cause of accidents. Once these issues have been identified, recommendations can be made for guidelines and standards for designing aviation systems and equipment, and training requirements that may aid the pilot in compensating for design limitations.

Error classification scheme and typology of flight crew errors.

Validated error reduction technologies.

REMARKS:

The development and application of a means for determining the causes of pilot error is specified as a high priority research area in ATA's research plan on human performance and aviation safety.

DATE: 1/15/85

ABSTRACT: 17

DATE OF REVISION: 12/30/87

OFFICES OF PRIMARY INTEREST: AFS-200, AIR-100, ANM-100, ACE-100, ASW-100

PROJECT TITLE: In-Flight Data Collection

OBJECTIVE: | Identify the characteristics of automated flight management systems that influence or contribute to their compatibility with human operators.

REQUIREMENT: | Currently, flight crews operate some automated flight deck systems with few errors, while errors are made much more frequently with other automated systems. There is little performance data to indicate the use or misuse of automated cockpit systems during actual flight. This information would be invaluable for determining principles for automation systems design.

APPROACH: | Conduct a voluntary and cooperative demonstration program between DOT and a U.S. commercial airline in order to collect in-flight data on aircrew use of automated flight management systems. Funding would be provided by the FAA. The confidentiality of the data would be assured through performance of data analysis by a third party (similar to ASRS).

RESULTS: | Identification of factors influencing system/crew compatibility to be considered in the modification of present systems and the design of future systems.

Recommendations on training requirements to facilitate efficient use of systems.

Communications to flight crews to be particularly alert to the possibility of certain kinds of errors.

REMARKS: | The FAA is currently supporting an effort by Boeing to collect data on errors by flight crews.

Discussions on the importance of such information have been held in a variety of committee meetings concerned with flight crew performance and automation. Representatives of ALPA have volunteered to promote and manage the collection of such data.

DATE: 1/15/85

ABSTRACT: 18

DATE OF REVISION: 12/30/87

OFFICES OF PRIMARY INTEREST: AFS-200, AAM-500

PROJECT TITLE: Fatigue and Crew Performance

OBJECTIVE: Determine the effects of fatigue on crew performance and develop countermeasures to alleviate the adverse effects.

REQUIREMENT: Fatigue is recognized as a major contributor to aircraft accidents and incidents. ASRS data indicate that decrements in flight deck performance and in the effectiveness of crew interactions are related to the time of day and are more severe during the final phases of flight, when fatigue is greater. The management of fatigue is becoming a serious problem, particularly as we acquire aircraft with longer flight durations and smaller crews.

APPROACH: Survey the literature on the influences of fatigue and sleep deprivation on social interaction, cooperative behavior, and leadership dynamics, and complacency.

Review accident investigation results to identify important flight crew and situational variables that are related to fatigue.

Based on data obtained above, conduct an experimental study that exposes flight crew test subjects to selected flight scenarios in a full mission simulator.

Evaluate the effects of controlled rest on crew alertness during critical phases of flight. This study would be conducted in actual line operations with appropriate safeguards.

Based on the results of these studies, develop strategies for fatigue management and evaluate their effects.

RESULTS: Documentation and summary of the effects of fatigue on crew performance and of the effects of controlled rest during long-haul flights.

Identification of fatigue-related variables affecting crew performance.

Recommendations for fatigue management.

REMARKS: This problem area is being researched by scientists at NASA-Ames. Work is being done on long- and short-haul flights as well as in simulators.

1. The first part of the document discusses the importance of maintaining accurate records of all transactions. This is essential for ensuring the integrity of the financial statements and for providing a clear audit trail. The records should be kept up-to-date and should be easily accessible to all relevant parties.

2. The second part of the document outlines the procedures for handling cash and other assets. It is crucial to ensure that all cash receipts are properly recorded and that there is a clear separation of duties between those responsible for collecting cash and those responsible for recording it. This helps to prevent errors and fraud.

3. The third part of the document discusses the importance of regular reconciliations. This involves comparing the company's records with the bank statements and other external records to ensure that they are in agreement. Any discrepancies should be investigated and resolved promptly.

4. The fourth part of the document outlines the procedures for handling accounts payable and receivable. It is important to ensure that all bills are paid on time and that all invoices are properly recorded. This helps to maintain good relationships with suppliers and customers and to ensure the accuracy of the financial statements.

5. The fifth part of the document discusses the importance of maintaining accurate records of fixed assets. This includes recording the purchase of new assets and the depreciation of existing assets. This information is essential for determining the true value of the company's assets and for calculating the correct amount of depreciation expense.

6. The sixth part of the document outlines the procedures for handling payroll and other employee-related expenses. It is important to ensure that all payroll records are accurate and that all taxes are properly withheld and paid. This helps to ensure compliance with applicable laws and regulations.

7. The seventh part of the document discusses the importance of maintaining accurate records of all other expenses. This includes recording the purchase of supplies, travel expenses, and other miscellaneous items. This information is essential for determining the true cost of the company's operations and for calculating the correct amount of expense.

3.6 Crew Training

DATE: 1/15/88

ABSTRACT: 19

DATE OF REVISION: 12/30/87

OFFICES OF PRIMARY INTEREST: AFS-200, ASO-205

PROJECT TITLE: Cockpit Resource Management/Line-Oriented Flight Training

OBJECTIVE: Improve flight crew training by incorporating the principles of cockpit resource management (CRM) and increasing the effectiveness of line-oriented flight training (LOFT).

REQUIREMENTS: Cockpit resource management is recognized as an important factor in the safety of cockpit operations. Accident investigators have repeatedly reported inadequacies in the execution of procedures and control use during in-flight emergencies. While line-oriented flight training (LOFT) has the potential for increasing the effectiveness of flight training, LOFT can also be used ineffectively; flight scenarios may be inadequate or familiar and predictable. Since the FAA has responsibility for the approval of training programs, an examination of the effectiveness of CRM and LOFT is warranted.

APPROACH: Review the emergency procedures training requirements in FARs 121/135 to evaluate their adequacy in meeting current flight safety requirements. Determine whether these procedures are consistent with the principles of cockpit resource management.

Survey airlines to determine specific practices in the application of LOFT and cockpit resource management training.

Survey pilots to identify deficiencies and weaknesses in company training programs.

Using data from actual LOFT sessions, identify human performance safety issues.

Analyze crew performance in LOFT to identify safety issues that need to be addressed (e.g., in training, changes in operational procedures, etc.)

Develop materials and program guidelines for CRM programs that are independent of LOFT for air carriers without LOFT capabilities.

RESULTS: Recommendations regarding changes in approval requirements for the use of LOFT and cockpit resource management training.

REMARKS:

DATE: 1/15/88

ABSTRACT: 20

DATE OF REVISION: 12/30/87

OFFICES OF PRIMARY INTEREST: AFS-200, AFS-800, AAM-500

PROJECT TITLE: Training and Evaluation of Pilot Judgment

OBJECTIVE: | Develop and evaluate training materials and techniques for improving pilot judgment and decision-making.

REQUIREMENT: | NTSB accident data suggests that approximately half of all general aviation fatal accidents involve judgment errors by the pilot. A review of the literature on judgment revealed that the motivational and intellectual aspects of judgment can be learned. The FAA, in cooperation with the General Aviation Manufacturers Association and Transport Canada, has developed prototype training curricula. This curricula has been formulated into manuals. Methods for instruction need to be specified. Its effectiveness in reducing pilot error in judgment, must be evaluated.

APPROACH: | Evaluate manuals at selected FBOs, Canadian colleges, and in the FAA's Eastern Region.

Develop methods for use by designated examiners and evaluate their effectiveness by assessing pilot judgment during flight and written tests for private pilot licenses.

Update manuals based on results and prepare final manuals for instrument pilot training.

RESULTS: | Decision-making training manuals have been published for: student, private, and instrument-rated pilots; flight instructors; and helicopter pilots in Emergency Medical Services operations.

DATE: 1/15/85

ABSTRACT: 21

DATE OF REVISION: 12/30/87

OFFICES OF PRIMARY INTEREST: AFS-200, AS0-205

PROJECT TITLE: Training Simulator Fidelity Criteria

OBJECTIVE: Determine minimum levels of simulator fidelity required to achieve selected training objectives. Identify the training that is necessary in order to perform selected aviation tasks and to qualify for credit toward regulated flight training.

REQUIREMENT: The amount of simulator training that is necessary to satisfy flight training requirements currently is determined by regulation. The regulations reflect the assumption that the more realistic the simulation, the greater the value of training. However, the level of fidelity on represented parameters (e.g., visuals, edges of flight envelope, ground handling, etc.) required to satisfy these regulations has not been empirically determined.

APPROACH: Through use of the Airman Certification System Development tool (an analytical and evaluational method used in the development of new simulator requirements):

- Identify the training and checking conditions within which the simulator will be deployed;
- Apply the ACSD method for each of these conditions in order to determine the simulator characteristics required to reach the training goal;
- Develop simulators with varying levels of fidelity;
- Expose a representative sample of pilots to training at selected levels of fidelity and determine the amount of simulator experience required to achieve training objectives at each level of fidelity; and
- Assess the differential effectiveness of the various levels of fidelity on pilot performance.

RESULTS: A validated method for determining minimum fidelity requirements for simulators to be used in training, reviews, and checking.

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DATE OF REVISION: 12/30/87

OFFICES OF PRIMARY INTEREST: AFS-200, ASO-205

PROJECT TITLE: Training Simulator Fidelity Criteria

Continued

REMARKS: | This methodology is based upon the work of David C. Gilliom (AFS-3) and H. Jan Demuth.

DATE: 1/15/85

ABSTRACT: 22

DATE OF REVISION: 12/30/87

OFFICES OF PRIMARY INTEREST: AFS-200, AFS-800, AS0-205

PROJECT TITLE: Simple Simulators

OBJECTIVE: | Identify the extent to which inexpensive simulators and part-task trainers can be used in the training of pilots.

REQUIREMENT: | The introduction of new "high technology" systems in existing aircraft requires additional operator training in order to ensure proper use of these new systems. The purchase of flight simulators that meet the requirements of the regulations for the training of pilots is generally out of the question (for economic reasons) for small airlines or air taxi operations. The development of low cost simulators may facilitate wider use of these devices, which may result in enhanced safety.

APPROACH: | Identify potential training applications for low-cost training devices. In particular, examine the use of part-task simulators for keeping flight crews current on complex flight deck management systems (FMS, PMS).

Assess the capabilities of currently available devices.

Evaluate the utility of selected low-cost simulators with regard to specific training applications.

RESULTS: | Recommendations and guidelines for the use of low-cost and part-task simulators.

Design and performance specifications, and acceptable training applications for simple and part-task simulators.

REMARKS: |

DATE: 1/15/85

ABSTRACT: 23

DATE OF REVISION: 2/17/88

OFFICES OF PRIMARY INTEREST: AFS-200, ASO-205

PROJECT TITLE: Performance Feedback in Simulators

OBJECTIVE: Increase the use and effectiveness of simulator training for developing and maintaining flying proficiency.

REQUIREMENT: Major air carriers make extensive use of advanced simulators for recurrent, differences, and upgrade training. Company personnel who train and check aircrews in these devices have the opportunity to observe and record the particular skills that are subject to degradation with time, the influences of flying automated aircraft on the retention of manual flight skills and the areas of weakness that are peculiar to individual flight crews. The use of computers to operate the flight simulators and to monitor the performance of the operators (pilots) and their own observations provide training personnel considerably more information on training and operational requirements than that reflected in the limited pass-fail feedback that is often transmitted to the crews in training. This limited feedback to pilots and the same data on the training records that are normally kept are of minimal analytical use. More detailed and objective information that describes what the pilots actually did, rather than the more common "pass-fail" system, would facilitate the streamlining of flight crew training requirements and would help to detect operational conditions that contribute to the degradation of flying skills. Such data could also be used to assess the impact of changes in training and procedures that may be implemented to ensure the maintenance of those skills.

APPROACH: Identify or develop critical flight scenarios.

Identify performance measures to be quantified.

Use the initial and recurrent training programs in simulators to establish a pilot performance data base using commercial airline pilots.

Use the data base to develop parametric measures of performance in simulator training.

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DATE OF REVISION: 2/17/88

OFFICES OF PRIMARY INTEREST: AFS-200, ASO-205

PROJECT TITLE: Performance Feedback in Simulators

Continued

APPROACH: | Determine the content and format of feedback that should be provided to the pilots, the training staff, and the air carriers.

Develop guidelines for the interpretation and use of simulator training and checking data for improving company training programs and for analyzing in-flight operational procedures.

RESULTS: | Guidelines for establishing and using computerized simulator training data for determining and streamlining flight crew training requirements.

Guidelines for using simulator training and checking data for evaluating company flight procedures.

REMARKS: |

DATE: 12/1/88

ABSTRACT: 24

DATE OF REVISION: 2/17/88

OFFICES OF PRIMARY INTEREST: AFS-200

PROJECT TITLE: Selection, Training, and Certification of Airmen

OBJECTIVE: | Ensure that criteria for the selection, training, and certification of airmen reflect current and anticipated knowledge, skills, and abilities necessary to satisfy the operational requirements of the increasingly complex flight environment.

REQUIREMENT: | The knowledge, skills, and abilities necessary to operate aircraft in the increasingly complex and increasingly automated flight environment have not yet been determined.

APPROACH: | Review Federal Aviation Regulations on flight crew training to identify inconsistencies with current and anticipated operational requirements.

Conduct analyses of current and future flight crew tasks and responsibilities for Part 91, Part 121, and Part 135 operations. From these analyses, determine the abilities, skills, and knowledge required to accomplish these tasks in the current and anticipated flight environments.

Develop and evaluate selection and training criteria for airmen.

RESULTS: | Detailed lists of flight crew tasks and responsibilities.

Selection and training criteria for airmen.

Recommendations for revisions to Part 91, Part 121, and Part 135 training regulations.

RELATED WORK: | Review of FAR Part 61, Part 141, and Part 143: Job task analyses for pilots and flight instructors (OPM and Booz Allen, in progress).

Training and certification requirements for future flight crews (University of North Dakota, in progress).

BIBLIOGRAPHY

- Aarons, R.N., "Waypoint Insertion Errors," In: *BUSINESS AND COMMERCIAL AVIATION*, June 1988, pp. 78, 80, 82, 84-85.
- Billings, C., "Toward a Human-Centered Aircraft Automation Philosophy," NASA-Ames Research Center, Moffett Field, CA, 1988.
- Caro, P.W., "Flight Training and Simulation," In: *HUMAN FACTORS IN AVIATION*, E.L. Wiener and D.C. Nagel, Eds., Chap. 8, 1988.
- Chambers, A.B., and D.C. Nagel, "Pilots of the Future: Human or Computers," In: *COMMUNICATIONS OF THE ACM*, Chap. 28, November 1985, pp. 1187-1199.
- Edwards, E., "Introductory Overview," In: *HUMAN FACTORS IN AVIATION*, E.L. Wiener and D.C. Nagel, Eds., Chap 1, 1988.
- Ellis, S.H., M.W. McGreevy, and R.J. Hitchcock, "Perspective Display Format and Air Pilot Traffic Avoidance, In: *HUMAN FACTORS*, Chap. 29, 1987, pp. 371-382.
- Hopkin, V.D., "Air Traffic Control," In: *HUMAN FACTORS IN AVIATION*, E.L. Wiener and D.C. Nagel, Eds., Chap. 9, 1988.
- Nagel, D.C., "Human Error in Aviation Operations," In: *HUMAN FACTORS IN AVIATION*, E.L. Wiener and D.C. Nagel, Eds., Chap. 9, 1988.
- Office of Technology Assessment, "Safe Skies for Tomorrow: Aviation Safety in a Competitive Environment," OTA-SET-381, Washington, DC, 1988.
- Proctor, P., "McArtor Presses for Safety Gains, Airport Construction in 1988 Plan," In: *AVIATION WEEK AND SPACE TECHNOLOGY*, September 21, 1987, p. 36.
- Sears, R.L., "A New Look at Accident Contributions and the Implications of Operational and Training Procedures, (u), Seattle: Boeing Commercial Airplane Company, 1986.
- Stevens, S.S. "Machines Cannot Fight Alone," In: *AMERICAN SCIENTIST*, Chap. 34, 1946 pp. 389-400.
- Stokes, A.F., and C.D. Wickens, "Aviation Displays," In: *HUMAN FACTORS IN AVIATION*, E.L. Wiener and D.C. Nagel, Eds., Chap. 12, 1988.
- Wiener, E.L., "Testimony Before the House Subcommittee on Transportation, Aviation, and Materials," Washington, DC, May 1988a.

Wiener, E.L., "Cockpit Automation," In: *HUMAN FACTORS IN AVIATION*, E.L. Wiener and D.C. Nagel, Eds., Chap. 13, 1988b.

Wiener, E.L., and R.E. Curry, "Flight-Deck Automation: Promises and Problems," *ERGONOMICS*, Chap. 23, 1980, pp. 995-1011.

Wiener, E.L., and D.C. Nagel, D.C. (Eds.), *HUMAN FACTORS IN AVIATION*, (Academic Press, San Diego, 1988).



