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SELECTED HUMAN FACTORS PROBLEMS IN CIVIL AVIATION
(a preliminay list)

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1.0 MAN/MACHINE INTERFACE

1.1 Cockpit

1.1.1 Design Considerations

- Human Factors Repository: A central repository of human factors information is not available to designers of aviation systems.
- Crew Fatigue: The effects of different flight deck operations upon crew fatigue levels are not understood.
- Error Types and Frequencies: The specific errors made by crew members in their use of cockpit equipment, the frequency of these errors, and the conditions under which errors are made are not known.
- Failure Analysis: Currently no specific, generally accepted methodology is widely used by the manufacturers of aviation systems for systematically determining human performance failures that could occur in using those systems.
- Function Allocation: A widely accepted technology for allocating flying functions to man or machine does not currently exist.
- System Add-Ons: Human factors are often ignored in the development and integration of systems for for use on new or older aircraft.
- Integration: Requirements and procedures for integrating ground and airborn systems to maximize pilot effectiveness do not exist.

1.1.2 Automation

- Implications: The implications of cockpit automation for workload limits, task involvement demands, heads down time, etc. are not understood.
- Status Monitoring: There is a lack of clarity concerning the information and techniques required to monitor the status of automated flight systems, e.g., autoland, so that crew members are able to detect and react appropriately to automation malfunctions.
- Flight Information and Control: Cockpit designers do not have a good grasp of the information that is required to fly advanced aircraft in cases of automation failures. For example, there is a need to perform research and to determine the information and control that a DC-10 pilot needs in order to safely land the aircraft when the autoland system fails under zero zero conditions.
- Pilot Proficiency: Increased reliance by pilots on automated flight systems may reduce pilot proficiency in manual flight during equipment outages.

1.1.3 Displays

- Altimeters: Pilots continue to make errors in reading altimeter displays.

- Cockpit Standardization: The absence of standardized controls and displays in general aviation aircraft contributes to pilot errors.

- Pilot Familiarity: Pleasure pilots' unfamiliarity with the operations of their newly acquired aircraft contributes to the incidence of general aviation crashes.

- Standardization of Glass Cockpit Symbology: Bugtypes, display symbology and control shapes are not standardized in the new glass cockpits.

- Standardization of Commercial Aircraft Cockpits: The location, size and shape of many controls and displays in existing commercial aircraft are not standardized.

- Color Displays: Cockpit designers to not take sufficient advantage of color displays.

1.1.4 Controls

- Voice Interactive Systems: There are no performance guidelines either for determining the conditions under which voice interactive systems may be used, or for determining the charactersitics of such systems which will make them safe for use in aircraft cockpits.

- Sidearm Controllers: Several airframe manufacturers are doing research on sidearm controllers and anticipating their deployment in civilian aircraft. Yet, performance guidelines for determining the conditions under which these controllers may be used in civilian aircraft or for determining the most acceptable configurations for their deployment have not been developed.

1.1.5 Alerts and Warnings

- False Alarms and Uninformative Warning Systems: Commercial aircraft alert and warning systems often generate false alarms and do not always provide information on the source of the trouble.

- Take Off Warnings: Take off warning horns do not identify specific problems, for example, whether the problem is flaps, spoilers, or stabilizer setting.

1.1.6 Visual Anomalies, Visibility Standards and Misperceptions of Size and Distance: Empty field myopia, night myopia and hyperopia, and instrument myopia caused by visual imagery displays lead to misperceptions of size and distance in flight.

1.1.7 Information Enhancement

- Flight Path Control: Procedures for use of electronic Flight Path Control (altitude) devices in the cockpit are inconsistent and have not been standardized.

- Rotation Point: Use of time to speed and distance to speed markers are not accepted by the air carrier industry.

- Flight Path Angle: Flight instrument panels currently in use do not provide pilots with information on flight path angle.

- Altitude Estimation: Line pilots have trouble estimating vertical distance above airports during VFR landings. Reliable external distance cues may not be available and VASI and ILS equipment may be absent , as well.

- G/A Weather Displays: Weather displays in general aviation aircraft are inadequate.

1.1.8 Visibility Standards

- Many current aircraft do not meet the visibility standards specified in Title 14 of the CFR.

1.1.9 Design Induced Errors

- Fuel Controls: The relationship between fuel selector switch movements and switch function is illogical, and the relationship between fuel gauages and fuel selector switches is unclear.

- Standardization of Critical Controls: Critical controls are not standardized.

- Labeling of Controls: Controls may be poorly labeled.

- Manuals: Manuals may include inconsistent specifications of take off distances and speeds with different flight configurations (flap positions, gear position, etc.). Manuals for many light aircraft are not sufficiently detailed with regard to unusual operating characteristics. For example, take off speeds for other than hard surfaced runways may not be specified and there may not be instructions for restarting engines after inflight fuel starvation.

1.2 Maintenance

1.2.1 Aircraft Design

- Ease of Maintenance: Aircraft are not designed for easy maintenance. This results in some maintenance items being systematically overlooked with consequent reductions in flight safety.

- Checking Condition of Aircraft: Aircraft may not be designed so that their readiness for service is apparent. For example, oil filler caps may appear to be screwed on when they are not.

1.2.2 Instruction Placards

- Composition and Placement: Instruction placards mounted on aircraft are sometimes poorly written and poorly placed. The instruction placard for filling the DC-10 hydraulic reservoir is one example that has been noted.

1.2.3 Manuals

- Composition and Contents: Maintenance manuals are not designed for the user. They are not written in a straightforward language, do not provide step-by-step procedures, and do not identify tools required for specific complex jobs.

- Standardization of Language: Terminology and nomenclature in maintenance manuals is not standardized.

2.0 PILOT PERFORMANCE

2.1 External Stress

2.1.1 Noise and Vibration

- Standards: There are neither data nor usable standards regarding the influence of noise and vibration upon pilot performance.

2.1.2 Fatigue

- Physiological and Environmental Correlates: Identification and understanding of the physiological and environmental aspects of fatigue and countermeasures for the effects of fatigue during long flight duty periods is needed.

- Fatigue and Time Zone Changes:
  - The cumulative effects on pilot performance of fatigue and desynchronosis due to transit through multiple time zones are neither understood nor adequately considered in airman duty-time regulations;
  - Little is known about the interaction of desynchronosis with physical condition and age.

2.2 Internal Stress

2.2.1 Life Stress

- Stress and Pilot Error: A relationship between life stress and the probability of pilot error is suspected but not verified for civilian pilots.

2.2.2 Licit Drugs

- Understanding and Guidelines: There is a lack of understanding or guidelines on the use of therapeutic drugs by pilots including:
  - Quinine water effects on inner ear functions;
  - Enderin (cardiac medication) reduction of pilot sensitivity to negative G forces; and
  - Antihistamine interaction with altitude, leading to hypoxia.

2.2.3 Alcohol

- Contribution to Crashes: Alcohol is associated with approximately 16 percent of fatal G/A crashes. Problems contributing to crash likelihood include:
  - Pilot drinking;
  - Pilot bravado;
  - Complacency of before-flight witnesses; and
  - Complacency of passengers.

2.2.4 Biorhythms

- The relationship between biorhythms and pilot performance is not understood.

2.3 Measurement

2.3.1 Workload

- Assessment Methodology: Currently there is no universally recognized method for assessing pilot workload. Designers and manufacturers need such a method to assess cockpit control and display alternatives.

2.3.2 Effects of Changes in Equipment and Procedures on Operator Performance

- Measurement of Long-Term Effects: Means for determining long-term effects of changes in equipment and procedures on operator performance are not available.

2.3.3 Long-term Effects

- Measurement and Evaluation: Broadly accepted methods are not available for evaluating gradual, long-term changes in functional and operational capabilities of aviation personnel that may be produced by medication, life experiences, aging, exposure to agricultural chemicals, and by microwave radiation.

2.3.4 Fatigue and Complacency

- Measures of Readiness to Perform: Methods which are satisfactory for operations-oriented research, or for monitoring operator alertness while on the job, are not available for measuring the relationship between fatigue and arousal and the readiness of pilots and controllers to perform.

2.4 How Pilots Fly

2.4.1 Information Requirements

- Flight Cues: There is only limited information concerning the cues that pilots use to fly, the relative importance of these cues, how they relate to one another, and their specific influences on flying behavior.

2.4.2 Obtaining Information

- Cockpit Displays: The manner in which pilots extract information from cockpit displays is poorly understood.

2.4.3 Workload

- Task Involvement Levels: The optimum levels of task involvement for minimizing the liklihood of human errors are not known.

3.0 REGULATORY ISSUES

3.1 Flight Crew

3.1.1 Crew Compliment

- Compliance with FAR 24.1523, Appendix D: There are no specific human performance or data analysis requirements in the FAA Engineering Flight Test Guide for determining crew compliments or for demonstrating compliance with FAR 24.1523, Appendix D.

3.1.2 IFR Training and Certification

- Weather: Current flight time qualification requirements for IFR training may contribute to the incidence with which VFR pilots fly in IMC, and crash.

- Terrain: General aviation pilots receive IFR certification without regard to the type of terrain that they fly over.

3.1.3 BFR

- Flying Skills: Regulations for recertification of G/A pilots do not take adequate account of the degeneration of flying skills over time. Adequate demonstration of flying proficiency is not required.

3.2 Aircraft

3.2.1 Instrumentation

- Currency: Regulations for cockpit instrumentation are out-dated. They do not include requirements for current state-of-the-art instruments, and do not represent the needs of modern, commercial aviation.

3.2.2 Certification Procedures

- Human Performance Testing: FAA requirements for assessing human performance factors in the certification of aircraft systems and controls is vague.

- Use of Line Pilots: The FAA does not use line qualified pilots in the certification process. That is, the pilots who certify aircraft are not those who are most familiar with the environment in which the aircraft that they are certifying will be used.

- Oversight: General aviation aircraft may be certificated although deficiencies in their design may result in unsafe flight characteristics under certain conditions. One type of aircraft for example, has been reported to have a strong tendency to roll if it is close to stall speed, with its landing gear and flaps down, if power is applied for a go-around attempt.

3.3 Maintenance

3.3.1 Certification

- Qualification of Mechanics: There is no requirement for recurrent certification of mechanics, and thus no assurance that mechanics are trained in servicing modern technology equipment.

3.3.2 Violations

- Inspection Oversight: Lack of rigor in inspections may permit operators to modify aircraft to below certificated limits. It has been alleged, for example, that a plane recently crashed because the left engine failed and the blade on the remaining engine had been filed below minimums.

3.3.3 Aircraft Design

- Assembly Errors: Aircraft designs permit assembly errors by maintenance personnel. On some aircraft, aelerons can be rigged in reverse, for example.

4.0 OPERATIONS AND PROCEDURES

4.1 Pre-Flight

4.1.1 Inspections

- Checklists: Many General Aviation pilots do not use checklists during pre-flight inspections; these inspections may, therefore, be incorrectly conducted.

- Flight planning: Inadequate flight planning is a major cause of general aviation crashes resulting from:
  - fuel exhaustion;
  - no identified alternative airports;
  - weight allowances exceeded; and
  - weather charges unanticipated.

4.1.2 Rental Procedures

- Flight Objectives Checks: Checkout procedures for rental aircraft are often incomplete and the purposes for which the aircraft will be used are not taken into account in releasing the aircraft for use by customers.

4.1.3 Weather Information

- Pilot Omissions:
  - Unless specifically requested, pilots may not be advised of critical SIGMETS at FSS briefings;
  - Many pilots do not request weather updates when en-route; and
  - Pilots misjudge severity of weather and their own ability to fly in IMC.

4.1.4 Crews for Commercial Flights

- No criteria or guidelines for assembling crew members for commercial flights currently exist.

4.2 En Route

4.2.1 Storm Avoidance

- Company Policies: Airline companies' storm avoidance policies may be impractical and insufficient. Realistic guidelines to assist line pilots in making decisions about flying in stormy conditions are needed.

4.2.2 Air Crew Fatigue

- Sleep Disruptions: Long, East-West transport flights may lead to sleep disruptions and associated fatigue on the part of the flight crew members.

4.2.3 Altitude Assignment Violations

- o Monitoring Flight Progress: Despite complex systems of alerts and warnings, line pilots commonly violate altitude assignments. This may result from misunderstandings and/or failures to monitor the progress of the flight.

4.3 Approach and Landing

4.3.1 Charts and Approach Plates

- o Symbology and Clutter: Sectional charts and approach plates are difficult to read and may be misleading:
  - the symbology used on NOAA and Jeppson charts is not the same;
  - charts are cluttered, and
  - the importance and order of use of information is ignored in approach plate layouts.

4.3.2 Visual Separation

- o See and Avoid: Pilots do not, and perhaps cannot see all of the other aircraft that they are in danger of colliding with and need to avoid.

4.3.3 Workload

- o Single Pilot: Flight procedures and activities required at high density terminal areas may easily overload the single pilot. For example, when forced to make a go around, the pilot must reconfigure the aircraft, pick up new headings, change radio frequencies and engage in ATC communications.

4.3.4 Noise Abatement

- o Standardization of Procedures: Noise abatement procedures at different airports are not standardized and may place unacceptable workloads on pilots.

4.3.5 Minimum Separation

- o Margin for Error: Lower minimums resulting from improved approach and landing aids decrease the pilots' margin for error and therefore may decrease flight safety.

4.3.6 Non-Flight Related Activities

- o Critical Flight Phases: During critical phases of flight, flight crews may be encumbered by non-flight related activities, such as obtaining airline connection information for passengers, while maneuvering during final approach.

4.3.7 IFR/VFR Transition

- o Reduction of Minimums: Transition from IFR to VFR when landing in low visibility conditions is becoming more and more dangerous as flight minimums are reduced.

4.3.8 Landing Proficiency

- o Automation: The reliability of modern aircraft may lead to complacency on the part of pilots and this, in turn, may lead to reductions in their readiness to anticipate and respond effectively in emergency situations.

- o Duty Time Limits: Flight crews assigned to international flights do not get sufficient practice in landings to retain acceptable levels of proficiency. Monthly duty time limits, long distances flown between landings, and sharing of the few landings that are made by captain and first officer contribute to this problem.

- o Feedback: Line pilots receive little feedback on their landing performance. As a result, their proficiency may deteriorate.

4.4 Maintenance

4.4.1 Complacency

- o Periodic Inspections: Complacency in conducting periodic inspections of commercial aircraft results in undetected flaws and reductions in safety margins. For example, X-ray negatives showing fractures in the wing of a DC-9 were examined during six separate inspections without detection of the flaws.

4.4.2 Errors

- o Installation of Parts: Installation of incorrect parts and incorrect installation of correct parts incorrectly contribute to crashes of commercial and general aviation aircraft.

4.4.3 Communications

- o Maintenance to Pilot: There is a lack of reliable procedures which insure that owners and pilots of pleasure aircraft are informed of incomplete maintenance. A Beech 99 out of Richmond allegedly failed because the pilot was not informed of a faulty stabilizer actuator which had been discovered earlier by a mechanic but not repaired.

- o Pilot to Maintenance: There is a lack of reliable procedures which insure that the owners and pilots of pleasure aircraft adequately inform maintenance personnel about problems in need of attention. This results in inadequate maintenance and reduces the safety of the aircraft.

- Maintenance Shift Change Briefings: Maintenance personnel going off-shift may not adequately brief personnel coming on-shift about the status of the aircraft that they are repairing. For example, it was alleged that, in one instance, incomplete briefing of maintenance personnel at shift change resulted in the engine cowling of a DC-10 blowing of in flight. Three different maintenance shifts serviced the aircraft, in sequence, and the second two shifts were inadequately briefed on the status of the repairs.

4.5 Communications

- Workload: There are too many ATC communications demands on pilots during critical phases of flight, e.g., during final approach.

- Errors: Causes of communication errors between controllers and pilots include:
  - cockpit noise
  - aircraft call sign confusions
  - pilot expectations
  - failure to follow communications procedures

- ATC Upgrade: There is a lack of planned effort to assure that degradation of pilot/controller relationships does not occur during ATC system upgrade.

5.0 TRAINING

5.1 Commercial Pilots

5.1.1 Crew Skills/Aircraft Operations Mismatch

- Pilot Qualifications: Some pilots who are flying commercial aircraft are not currently qualified to do so. Standards and procedures presently used to classify and identify pilots in terms of qualification levels are not always effective.

- Curricula Currency: Development and deployment of pilot training curricula lags behind cockpit technology. For example, some pilots are unfamiliar with procedures required to bypass autoland in instances of system failure or final approach procedure changes.

- Pilot Knowledge of System Capability: Mismatch between systems used and operators' understanding of systems may result in failure to use systems due to lack of confidence in them. This, in turn, may result in decisions, such as shooting the minimums, that lead to unnecessary risk.

- ATP Emergency Training: Flight crew personnel may not receive sufficient instruction in implementation of emergency procedures. This may result in inappropriate and ineffective reactions by flight crews in emergency situations such as aborted take offs.

- Communter Airline Operator Emergency Training: Because of financial constraints, commuter airlines may be unable to provide simulator training in emergency procedures for their flight crews, resulting in impaired ability to deal effectively with certain inflight emergency conditions.

- First-Officer-For-Command Training: First officers working for emergent airlines which, because they have financial difficulties, cannot affort to provide adequate training, may be promoted to command positions without being thoroughly trained for that job.

- Cockpit Resource Management: Deficient human relations and management capabilities in command officers may decrease flight safety in high workload and in other situations requiring effective cooperation among crew members.

- Requirements: Currently there is no specific requirement that air carrier crews receive formal training in the management of cockpit resources.

5.2 General Aviation Pilots

- Familiarity with Aircraft: Second and third owners of light aircraft are not as adequately trained in operating the aircraft and its equipment as are original owners.

- Emergency Procedures: General aviation pleasure pilots are not trained to handle in-flight emergencies such as:
  - engine failure
  - control malfunctions
  - unanticipated weather

- Unusual Flight Conditions: Many general aviation pilots are unfamiliar with aircraft capabilities under unusual conditions of flight:
  - short field take offs
  - extreme cross winds
  - combinations of conditions

- Flight Instructor Qualifications: Certification of flight instructors does not consider their teaching ability.

5.3 Simulation

- Substitution for Flight Time: The characteristics of simulation which are required for training in flight simulators to adequately substitute for training in actual aircraft have not been determined.

- Real Flight Expectations: The influence of simulation training on expectations in real flight is unknown.

5.4 Maintenance

5.4.1 Curricula

- Advanced Electronics: Currently, training requirements for avionics technicians do not include expertise in microprocessing technology. This knowledge is necessary to service advanced avionics systems.

- Airframe Repair: Schools are not equipped to teach repair of bonded structures or honeycomb structures to airframe mechanics.

- Avionics: There is no current standardized curriculum for training mechanics to repair advanced avionics systems.

5.4.2 Assessment

- Trouble Shooting Skills: Skills in trouble shooting and problem solving are not measured by current certification tests for aircraft maintenance personnel.

- Test Instruments: There are no validated instruments for assessing the usefulness of current practices for teaching A & Ps to maintain modern, sophisticated aircraft.

5.4.3 Skill/Job Requirement Mismatches

- Military Training: Aircraft mechanics who are trained in the military may be certificated to assume responsibility for civil aircraft repairs and inspections without being required to attend FAR 145 school.
- Maintenance of Avionics: Aircraft mechanics who have not been trained in, or examined on the requisite skills are expected to maintain and certify complex avionics in light aircraft.
- Certification Authority: Mechanics may repair and certify aircraft with which they have no current experience. For example, licensed A & Ps whose current experience is limited to turbine engines are also authorized to repair, inspect and certificate reciprocating engine aircraft.

6.0 ACCIDENT INVESTIGATION

6.1 Deficiencies in General Procedures

- Information Sharing: The civil aviation section does not take advantage of investigatory techniques or safety information developed by D.O.D.

- Non-Fatal Accident Investigations: Non-fatal accidents are not thoroughly investigated although the characteristics of these accidents may be practically identical to those of accidents resulting in fatalities. Therfore, opportunities to obtain first-hand accounts from persons involved in accidents are lost.

- Comparability of Data from Accident Investigations: Criteria for determining the detail with which accident investigations are conducted are not standard. Therefore, levels of detail are not uniform across investigations and the results of different investigations may not be comparable.

- Investigation of Commercial Aviation Accidents: Investigations of commercial aircraft accidents are not conducted by people trained in human factors engineering who are also familiar with flight operations and flight deck equipment.

- Uniformity: The lack of uniformity and thoroughness of investigations of general aviation crashes reduces the usefulness of data produced by those investigations.

- Configuration of General Aviation Aircraft: Detailed information on control settings and equipment compliment is often not obtained.

- Maintenance History: There is often little attempt in accident investigations to determine the reason for maintenance errors (or inactions) that contribute to airplane crashes from mechanical failure.

- Data Collection Forms: The new NTSB accident investigation forms structure the investigators' thinking in ways that may interfere with the discovery of what really happened.

6.2 Determination of Pilot Error

- Limited Use of Flight Data Voice Recordings: Currently, DFR and CVR are not sufficiently used to enable thorough understanding of role of pilot error in crashes.

- Inaccuracy: DFR equipment in crashed aricraft have provided inaccurate information on aircraft flight parameters.

- Lack of Transcribing Equipment: Lack of equipment to transcribe CVR records has reduced their utility in accident investigations.

- Flight Crew Testimony: Accident reports frequently do not include pilots' testimony in explanation of pilot errors.

- Critera for Attributing Aircraft Accidents to Pilot Error and Other Human Factors: Specific criteria for determining the extent to which aircraft accidents are due to pilot error have not been established.

- Insufficient Data: Insufficient data on crew performance and characteristics are collected during accident investigations to specify human errors that contributed to a crash and why these human errors occurred. For example, insufficient information was collected in the case of Pensacola 727 crash to determine why the flight engineer turned the GPWS off.

- Pilot Characteristics: General aviation accident investigations do not collect sufficient information on pilot characteristics to enable analysis of the extent to which these characteristics contribute to crashes. For example, information on recency of flying experience may not be obtained.

- Work Environment: In most accidents, information on flight conditions and operational situations that promote pilot errors are not systematically addressed, e.g., cockpit design, pilot workload, environmental conditions.

6.3 Data Characteristics

- ASRS: ASRS data on inflight emergencies does not contain sufficient information for determining contributing human factors in these incidents.

- Data Base Organizations: Computerized safety data bases are not structured to facilitate analysis of human factors data.

- Exposure Data: The relative criticality of flight conditions and performance problems cannot be determined because of insufficient exposure data, e.g., reliable and representative data on pilot flying time under various conditions are not available.

- Application of Results: Currently there are no established procedures whereby the results of accident investigations can influence system design efforts and whereby suspected human factors problems in system designs can influence accident investigation procedures.

7.0 HELICOPTER OPERATIONS

7.1 Terminal Procedures

- Aircraft Mix: It is difficult to control and fly helicopters mixed with the faster, fixed wing aircraft within the context of current terminal procedures;

- Vertical Obstructions: It is difficult for helicopter pilots to see vertical obstructions near landing areas, such as antenna towers that are illuminated for detection by conventional aircraft, but not for detection by rotorcraft.

7.2 Cockpit Design

- Standardization: Extreme lack of standardization of displays and controls in helicopters contribute to transfer of training problems for helicopter pilots.

- Pilot Performance Data: There is insufficient pilot performance data to permit development of standardized guidelines for helicopter displays and controls.

- Seats: Anthropometric specifications for pilot seats to be used in helicopters are not available to cockpit designers.

7.3 Air Traffic Control

- Radar Clutter: Air traffic controllers have difficulty identifying helicopters on their radar scopes because helicopter returns often fall within radar clutter.

- Direction of Movement: Because of the nature of external lighting on helicopters, it is often difficult for arrival controllers to determine their direction of horizontal movement.

7.4 Helipad Design

- Low Altitude Navigation Aids: Design requirements for heliports are not well understood, particularly those for low altitude navigation aids.

8.0 AIRPORTS AND FACILITIES

8.1 Surface Lighting and Signing

- Standardization: Runaway and taxiway signs and lights are not standardized across airports and are difficult to see under conditions of restricted visibility. Often runways cannot be discriminated from taxiways.

- Ground Conditions: Information painted on the ground is lost in snow and fog.