

2.5 Human Factors and Aviation Medicine Program Area Description

Mission

The Human Factors and Aviation Medicine Program intends to: (1) conduct applied research to identify methods which, when implemented, will contribute to the goal of reducing the fatal accident rate by 80 percent; (2) introduce innovative research and management initiatives to ensure that human factors issues are addressed in the acquisition and integration of all new and modified FAA aviation systems; and (3) meticulously review medical patterns in civilian flight to develop recommendations for protective equipment and procedures as well as for standards and regulations to protect all aircraft cabin occupants.

The rapid evolution toward increased operational demand, diversity of aircraft and systems, changing technology, and globalization of the airline/aircraft industry pose a collective challenge to the Offices of Human Factors and Aviation Medicine. The program will meet its goals by: ensuring that research is focused on those areas directly impacting aviation safety; capitalizing on opportunities to leverage government and industry resources; forming partnerships with research and university laboratories in order to rapidly transfer the results of research to the aviation community; and undertaking major efforts to ensure that human factors expertise is represented across functional disciplines and that human factors considerations are addressed across the FAA acquisition process.

Intended Outcomes

Human factors research is increasing the safety and efficiency of the National Airspace System (NAS) by developing scientifically validated information and guidance for improving the performance and productivity of air traffic controllers and NAS system maintenance technicians. This program directly responds to *FAA Strategic Plan* goals to "eliminate accidents and incidents caused by human error" and to "implement new decision support systems and associated functional

improvements that fully account for the proper role of people in the system." This research also provides human factors support that addresses the FAA goal to "reduce the costs of flying by making the air traffic management system more efficient to use." Human factors research is developing human-centered flight controls and displays, and is increasing considerations of human factors in aircrew training. This research also explores prospects for safety enhancement through automated statistical analysis of flight-recorded data and through certification of new aircraft and equipment design and modification. Human factors research develops more effective methods for inspector and maintenance technician training, and improves inspector and maintenance technician task performance. The program enhances the safety of general aviation through the improvement of pilots' decisionmaking skills.

Aviation Medicine research improves the health, safety, and survivability of aircraft passengers and aircrews by identifying human failure modes and developing formal recommendations for means to counteract their negative effects. On the basis of this research, the FAA develops the bioaeronautical guidelines, standards, models, and certification procedures which fulfill the agency's vital regulatory mandate. Thus, research findings result in an improved cabin environment through the introduction of better equipment.

Program Area Outputs

The Human Factors Program identifies operational needs and problems involving human performance; funds and guides research programs to address operational priorities; forms partnerships with industry and academia; elicits participation by the nation's top scientists and professionals; and facilitates transfer of research products to the operational community. The Aviation Medicine Program produces data and other forms of information which support notices and regulations applicable to aircraft occupant health and safety. It also develops output options in response to public demand (e.g., better restraints for children in aircraft

settings); and it assesses disease transfer and other aircraft occupant health factors.

The FAA works to ensure the safety and efficiency of NAS operations, a critical element of which is operator performance. Through guidelines, handbooks, advisory circulars, rules, and regulations, the agency provides industry human performance information and guidance critical to the design, operation, regulation, and certification of equipment, training, and procedures. The Human Factors Program performs the research which provides the technical information necessary to generate these products and services.

Automation has been cited as a contributing factor in aircraft accidents (e.g. Cali:AA065). Human factors research is examining flight deck automation design, operation, and use, and has developed a taxonomy of issues to be addressed. Air carrier training initiatives such as the Model Advanced Qualification Program (air carrier pilot training program which integrates both technical and crew resource management performance requirements) will allow air carriers to develop and utilize proficiency-based training. Pre-hiring screens for air traffic controllers will enable the FAA to select people with needed skills, thus reducing training required after employment. The Automated Performance Measuring System will allow airlines to analyze routine operations for dangerous trends and tendencies, and will provide insight into the details of daily carrier line operations.

The Aviation Medicine Office and the National Institute for Occupational Safety and Health (NIOSH) are examining cabin air quality issues and their effects on passengers and crew. Aviation Medicine is also developing bioengineering criteria to support aircraft seat and restraint system certification; biomedical criteria to support protective breathing equipment and operational procedures certification; and biochemical and toxicological criteria supporting the use or certification of aircraft interior fire, smoke, and toxicity limits.

Program Area Structure

The Human Factors program addresses operational requirements through research in the following five technical thrust areas (agreed to by the FAA, NASA, and DOD in the *National Plan for Civil Aviation Human Factors*):

Human-Centered Automation: This research focuses on the role of the operator and the cognitive and behavioral effects of using automation to assist humans in accomplishing their assigned tasks. Research in this area addresses the identification and application of knowledge concerning human strengths and limitations in an automated environment. It investigates the implications of computer-based technology in the design, evaluation, and certification of controls, displays, and advanced systems.

Selection and Training: Research in this area strives to: understand the relationship between human abilities and aviation task performance; enhance the measures and methods for the prediction of future job/task performance; establish a scientific basis for the design of training programs, devices, and aids for individuals and teams; define criteria for assessing future training requirements; and identify new ways to select aviation system personnel.

Human Performance Assessment: Research in this area identifies the intrinsic characteristics of individuals and teams which determine how well they are able to perform aviation tasks; characterizes the impact of environmental and individual factors on human performance; and improves and standardizes methods for measuring human performance.

Information Management and Display: Research in this area addresses the presentation and transfer of information among components in the NAS. It seeks to identify the most efficient and reliable ways to display and exchange information; determines when and how one might best display and transfer specific information to system components; designs a system to reduce the frequency of information transfer errors and misinterpretations; and strives to minimize the impact when errors occur.

Bioaeronautics: Research in this area involves the bioengineering, biomedicine, and biochemistry associated with performance and safety. The objective is to enhance personal performance and safety by maximizing crew and passenger health and physiological integrity. The program includes three research initiatives: human protection and survival; medical and toxicological factors of accident investigation; and Federal Air Surgeon program support. Protecting humans in decelerative environments, protective breathing equipment, cabin evacuation, and water survival are investigated in the human protection and survival initiative. Toxicological assessment and sudden or subtle pilot incapacitation are key features of the accident investigation initiative. New vision corrective methods for aviation personnel, aircraft cabin environmental hazards, and air ambulance medical requirements represent current clinical investigations under the Federal Air Surgeon program support initiative.

Customer/Stakeholder Involvement

The Human Factors Program directly supports a number of aviation community initiatives and congressional mandates:

- Office of the Associate Administrator for Research and Acquisitions Performance Plan, Goal 1 ("Through research, identify methods that, when implemented, would reduce the fatal aviation accident rate by 80 percent by 2007 when compared to 1990-1996 baseline data"), and Goal 2 ("Ensure that critical human factors issues are addressed in the acquisition and integration of 100 percent of new and modified FAA aviation systems by 2005").
- The *National Plan for Civil Aviation Human Factors*, published in March 1995, with FAA, NASA, and DOD as signatories. This document, which had extensive aviation community participation in its development, outlines a coherent national agenda for human factors and bioaeronautical research and application leading to significant improvements in NAS safety and efficiency.

- The *Aviation Safety Plan*, which calls for research supporting priority issues associated with crew training, safety data collection and use, application of emerging technologies, and aircraft maintenance procedures and inspection. The Aviation Medicine Program significantly contributes to the application of emerging technologies, as highlighted in the plan
- Implementation of the FAA report on "The Interfaces Between Flight Crews and Modern Flight Deck Systems."
- Public Law 100-591, which establishes requirements for human factors research and its application; the FY 1997 Department of Transportation Appropriations Act, which cites human factors as the greatest cause of aviation accidents and calls for high priority research; and The Aviation Safety Research Act of 1988, which requires that human factors research be conducted to "enhance air traffic controller performance, develop a human factor analysis of the hazards associated with new technologies, identify innovative and effective corrective measures for human errors, and develop dynamic simulation models of the ATC system."
- RTCA "Free Flight Action Plan," which specifically addresses recommendations to: establish more flexible decision support systems involving collaborative decisionmaking; conduct human-in-the-loop simulations for assessing controller and pilot perceptions of hazards, risks, and discomfort; measure performance, workload, and situation awareness associated with controller and pilot responses to time and distance; conduct real-time human-in-the-loop simulations to systematically study controller and pilot behaviors, interactions, and effects within NAS environments that represent dynamic densities and sector configurations anticipated for free flight.

The Aviation Medicine Program is an integral participant and research provider under the FAA, Joint Aviation Authorities, and Transport Canada's *Aviation*

Aircraft Cabin Safety Research Plan (established in 1995), which sets forth long-term research goals and ensures coordination among agencies.

Accomplishments

The program has accomplished the following:

- Developed and field tested (with several airlines) a prototype Automated Performance Measurement System to allow for the gathering and analysis of data from aircraft flight data recorders. This capability is utilized by the Flight Operations Quality Assurance Program, a joint FAA and airline venture to enhance aviation safety.
- Developed a model Advanced Qualification Program (AQP) for use by training centers to support regional air carrier participation in AQP, a proficiency-based approach to pilot training.
- Published the *Aircraft Maintenance Human Factors Guide*.
- Developed pilot performance data through flight simulation for use in establishing certification standards for general aviation autonavigation and control systems.
- Sponsored the National Research Council's assessment of human factors issues in the air traffic control system and the publication entitled *Flight to the Future - Human Factors in Air Traffic Control*.
- Conducted a human/system performance assessment of the Departure Sequencing Engineering Development Model.
- Completed a human factors audit of the Converging Runway Display Aid installed at St. Louis Airport to help terminal radar controllers efficiently space aircraft arriving on separate, converging runways.

- Measured taskload and document work processes of personnel at maintenance control centers.
- Developed guidelines to reduce inflight sudden/ subtle incapacitation.
- Evaluated autopsy data from fatal aviation accidents to recommend protective equipment and design practices.
- Assessed flight attendant reproductive health hazards.
- Reported on the suitability of component tests for showing regulatory compliance with crashworthiness standards for aircraft.
- Completed definitive evacuation escape slide angle and strength studies to minimize escape injuries and escape failures.
- Developed improved aviation oxygen mask systems.
- Assessed operational hazards of in-flight laser exposure.
- Evaluated effect of refractive surgery on vision tasks in aviation.
- Developed performance-based narrow and wide-bodied aircraft cabin evacuation approval guidelines.

R&D Partnerships

The Human Factors Program is linked to NASA and DOD under the auspices of the *National Plan for Civil Aviation Human Factors: An Initiative for Research and Application*. Specific areas of coordinated program execution with NASA include cockpit automation, fatigue, crew resource management, team decisionmaking, air-ground communication, and the Automated Performance Measurement System. DOD joint efforts involve fatigue, team performance, and decisionmaking research. Additionally, the Human Factors Office maintains

membership in the DOD Human Factors Engineering Technical Advisory Group which provides a forum for the coordination of research across a variety of technical areas.

The Human Factors Office participates with the Netherlands National Research Laboratory in flight deck automation research, and with the Office of Aviation Medicine. The office maintains an active membership on all Society of Automotive Engineers G-10 human factors subcommittees related to on-going and future research areas to ensure transition of the results to standards and guidelines. Members from the National Transportation Safety Board work with the Human Factors Office in the areas of fatigue, flight deck automation, and error mitigation. The Human Factors Office has awarded grants to eight universities supporting research on air carrier training, flight deck automation, human performance integrity, and aircraft maintenance technician training. Coordinated research efforts are conducted with NASA Ames in the areas of free flight and shift-work-induced fatigue and associated countermeasures. An Interagency Agreement with the U.S. Naval Air Warfare Center facilitates collaborative research in areas of selection and training. Additionally, elements of the controller performance research project are conducted in concert with the U.S. Air Force's Armstrong Laboratory.

The Office of Aviation Medicine participates with NIOSH on a collaborative study addressing the cabin environment and flight attendant and passenger symptomatology and diseases. A liaison is also maintained with the American Society of Heating, Refrigeration, and Air Conditioning Engineers Committee addressing aircraft cabin air quality status and research.

The Office of Aviation Medicine maintains direct cooperative research processes with all the manufacturers responsible for safety products (seats, restraint systems, oxygen masks, evacuation slides, etc.). The Office of Aviation Medicine is further represented on appropriate subgroups of organizations such as the

Aerospace Medical Association, the Civil Aviation Medical Association, and the Professional Aeromedical Transport Association. Appropriate liaison with the military is maintained either through direct project collaboration (e.g., crashworthiness, eye injury from lasers) or through the more global participation in the Tri-Services Aeromedical Research Panel, and the North American Treaty Organization aerospace medical advisory group.

Long-Range View

The FAA has accepted national responsibility to initiate and maintain research and development programs in support of modernization, regulation, certification, and NAS issues; and, with equal importance, national responsibility to initiate proactive research to identify emerging safety trends. The human factors investment strategy will directly support proactive research efforts to identify and reduce targeted safety issues.

Baseline data will be established to show direct causal relationships between research outputs and accidents and incidents. Research programs will be directed at targets which will have the greatest impact on aviation safety, will be multi-year efforts, and will require stabilized resources to plan, execute, and complete. Successful implementation of research outputs will require full partnerships and close cooperation within FAA organizations and the aviation community.

Research strategies will focus on technology, partnerships, and measurements. Methods will be developed to identify interventions to address human performance issues in flight maintenance and air traffic operations and to reduce operational hazards. A five-year integrated safety research plan will be developed with NASA to address long-range, high pay-off priorities. Measurement strategies will be developed to accurately monitor trends and identify opportunities for research to mitigate risks.

Public and Congressional interest is not abating for the maintenance of a healthy and comfortable environment for each category of civil aviation's participants. This concern is demonstrated by the activation of a new five-year interagency agreement between FAA and NIOSH in FY97 to address infectious disease and other health considerations in the aircraft cabin environment.

FAA goals related to minimizing injury, associated pain, necessary rehabilitation, and death as a consequence of aviation accidents make the work of the Aviation Medicine Program a critical component of coordinated steps to increase human survivability, one of the accepted corporate strategies for decreasing fatality accidents. The Aviation Medicine Program will emphasize reduction in the severity of injuries encountered in aviation accidents and in such precautionary events as evacuation of passengers from an aircraft after recognition of a safety concern by the flight crew. This approach will cut rehabilitation time, decrease medical costs, and improve the quality of life for persons who suffer injuries.

Additionally, in concert with the targets expressed in Challenge 2000 and with FAA's broad commitments to harmonize safety regulations on a global scale, the Aviation Medicine Program will focus its collaborative interactions with domestic and international laboratories to generate research data for use in the development of internationally harmonized aviation standards and regulations. Aeromedical research will be increasingly required to interpret data derived from around the world, and to assess if this data should be accepted or recollected before being integrated into regulatory considerations and outputs.

A08a Flightdeck/Maintenance/System Integration Human Factors

GOALS:

Intended Outcomes: The FAA intends to improve air transportation safety by:

- Developing more effective methods for aircrew, inspector, and maintenance technician training.
- Developing more human-centered flight controls and displays.
- Increasing human factors considerations in certification of new aircraft and equipment design and modification.
- Improving aircrew, inspector, and maintenance technician task performance.

Agency Outputs: The FAA is concerned with ensuring the safety and efficiency of operator performance, a vital element in NAS operations. Through guidelines, handbooks, advisory circulars, rules, and regulations, it provides industry with human performance information and guidance critical to the design, operation, regulation, and certification of equipment, training, and procedures. The Human Factors Program conducts and manages the research which provides the technical information necessary to generate these products and services.

Customer/Stakeholder Involvement: The Human Factors Program directly supports a number of aviation community initiatives:

- Office of the Associate Administrator for Research and Acquisition Performance Plan, Goal 1 (reduce fatal aviation accident rate by 80 percent) and Goal 2 (ensure that human factors are addressed in all new and modified FAA systems).
- The *National Plan for Civil Aviation Human Factors - An Initiative for Research and Application* was published in March 1995, with FAA, NASA, and DOD as

signatories. This document, which had extensive aviation community participation in its development, outlines a coherent national agenda for human factors research and application leading to significant improvements in NAS safety and efficiency.

- The *Aviation Safety Plan*, through research supporting priority issues associated with four of the six workshops: crew training, safety data collection and use, application of emerging technologies, and aircraft maintenance procedures and inspection.
- The implementation of the FAA report on "The Interfaces Between Flight Crews And Modern Flight Deck Systems."
- The Human Factors Program is responsive to Public Law 100-591, which establishes requirements for human factors research and its application.

Accomplishments

The programming output of data packages, models, and regulatory documents includes:

- Developed, and currently field testing with several airlines, a prototype automated performance measurement system (APMS) which allows for the gathering and analysis of data from aircraft flight data recorders. This information and analysis capability provides the backbone for the Flight Operations Quality Assurance Program, a joint FAA and airlines venture to enhance aviation safety.
- Developed an advisory circular and handbook on crew resource management for aircrew members.
- Developed a model Advanced Qualification Program (AQP) to include regional air carrier participation. This is a proficiency-based approach to pilot training that is considered to be highly effective and efficient for aircrew training.

- Published the *Aircraft Maintenance Human Factors Guide*.
- Provided educational outreach to the aviation community through the NASA/FAA fatigue countermeasures training module.
- Developed pilot performance data, through flight simulation, for use in establishing certification standards for general aviation autonavigation and control systems.
- Developed aircraft certification human factors and operations checklist for stand-alone global positioning system receivers.

R&D Partnerships: The program is linked to NASA and DOD under the auspices of the *National Plan for Civil Aviation Human Factors: An Initiative for Research and Application*. Specific areas of coordinated program execution with NASA include cockpit automation, fatigue, crew resource management, team decisionmaking, air-ground communication, and automated performance measurement system. DOD joint efforts are in fatigue, team performance, and decisionmaking. Additionally, the FAA is represented on the DOD Human Factors Engineering Technical Advisory Group, a forum for the coordination of research across a variety of technical areas. The FAA participates with the Netherlands National Research Laboratory in flight deck automation as well as on all of the Society of Automotive Engineers G-10 human factors subcommittees related to our research areas to ensure transition of the results to standards, guidelines, etc. Members from the National Transportation Safety Board have worked with the program in the areas of fatigue, flight deck automation, and error mitigation. The FAA also has extended grants to ten universities supporting research on air carrier training, flight deck automation, and aircraft maintenance technician training.

MAJOR ACTIVITIES AND ANTICIPATED FY 1998 ACCOMPLISHMENTS:

Selection and training.

- Provided proceduralized crew resource management guidelines for regional airlines.
- Validated human performance transfer functions for level B full flight simulator.
- Completed research and developed draft advisory circular on aircraft maintenance resource management.
- Completed guidelines for maintenance technician situation awareness training.
- Completed research and published draft advisory circular on training for automated flight deck operations.

Human performance assessment.

- Completed advanced APMS prototype.
- Completed user needs studies at air carriers participating in APMS development.
- Developed mapping of flight data parameters onto AQP qualification standards.

Human-centered automation.

- Completed human factors guidelines for assessing advanced general aviation transportation experiments (AGATE) cockpit controls/displays.
- Provided recommendations for improved utilization of automated flight management systems.

Information management and display.

- Completed software tools for enhanced maintenance documentation.

KEY FY 1999 PRODUCTS AND MILESTONES:

Selection and training.

- Provide tools for scenario based evaluations in line-oriented flight training.
- Implement advanced training techniques for general aviation pilots.

Human performance assessment.

- Define general aviation pilots decisionmaking skills required for training module development.
- Complete research and develop draft advisory circular on aircraft maintenance error detection/reporting systems.
- Develop and implement phase 1 APMS at partner air carriers.

Human-centered automation.

- Provide recommendations for improved utilization of automated flight management systems.
- Provide human factors evaluation for AGATE flight systems configurations.
- Develop certification guidelines for integrated technology in general aviation cockpits.

Information management and display.

- Develop guidelines for the use of simplified English in aircraft maintenance technician instructions and documentation.
- Develop flight data recording and analysis capability for flight simulators.

- Develop and publish secure internet flight information data warehouse standards.

FY 1999 PROGRAM REQUEST:

The program continues to focus on providing technical information and consultation to improve aircrew, inspector, maintenance technician, and aviation system performance. Emphasis is on developing guidelines, tools, and training to enhance error capturing and mitigation capabilities in the flight deck and maintenance environments; and developing human factors tools to ensure that human performance considerations are adequately addressed in the design and certification of flight decks and equipment.

A08b Air Traffic Control/Airway Facilities Human Factors

GOALS:

Intended Outcomes: The FAA intends to increase the safety and efficiency of the National Airspace System (NAS) by developing scientifically validated information and guidance for improving the performance and productivity of air traffic controllers and NAS maintenance technicians. This program is relevant to Fiscal Year 1996 FAA Strategic Plan goals to: "eliminate accidents and incidents caused by human error" (system safety goals #3A, B, & C) and to "implement new decision support systems and associated functional improvements that fully account for the proper role of people in the system" (system safety goal #4G). It also provides human factors support that addresses the Fiscal Year 1996 FAA goal to "reduce the costs of flying by making the air traffic management system more efficient to use" (system capacity goal #5C). This program is directly responsive to the Office of the Associate Administrator for Research and Acquisition Performance Plan, Goal 1 (reduce fatal aviation accident rate by 80 percent) and Goal 2 (ensure that human factors are addressed in all new and modified FAA systems).

Agency Outputs: This program develops research products that provide essential assistance to FAA's Air Traffic Services (ATS) for implementing and enhancing advanced operational concepts, including the systems, subsystems, and procedures integral to these concepts. The research products are distributed in the form of guidelines, reference handbooks, data bases, technical reports, checklists, and briefings. They are also shared with the international aviation community. The research is focused on the following issues:

- Producing guidelines and models for optimally allocating operational functions and tasks between human operators and their equipment.

- Creating qualitative and quantitative human factors reference information to assist in the design, integration, and evaluation of evolving air traffic control (ATC) and airway facilities (AF) systems.
- Using real-time simulations, rapid prototyping, and computational models to generate reference data that support FAA specifications, acquisitions, and tests for improving NAS equipment and procedures.
- Developing and applying analysis tools and standards for assessing/predicting operator workload and performance.
- Providing insight into the root causes of operational errors by creating the capability to integrate routinely-recorded radar and voice transmission data into a radar display format that re-creates events from the perspective of the air traffic controller.
- Developing and validating tools and reference information for improved controller selection and training programs.
- Identifying the effects of rotating shift work on operator performance and offering effective countermeasures to potential negative impacts.
- Analyzing pilot-controller miscommunications and providing recommendations to reduce the likelihood they will recur.

Customer/Stakeholder Involvement: The Air Traffic Control/Airway Facilities Human Factors R,E&D program directly supports the following aviation community initiatives:

- It is responsive to The Aviation Safety Research Act of 1988, section 3, wherein Congress stipulates that human factors research be conducted to: enhance air traffic controller performance; develop a human factor analysis of the hazards associated with new technologies; identify innovative and effective

corrective measures for human errors; and develop dynamic simulation models of the ATC system.

- Research directly supports the RTCA Free Flight Action Plan by specifically addressing the following recommendations: #8, "...establish more flexible decision support systems [involving collaborative decisionmaking];" #33f, "...conduct human-in-the-loop simulations for assessing controller and pilot perceptions of hazards, risks, and discomfort. Performance, workload, and situation awareness associated with controller and pilot responses to time and distance buffers will be measured;" and #34, "Real-time human-in-the-loop simulations should be conducted to systematically study controller and pilot behaviors, interactions, and effects within NAS environments that represent dynamic densities and sector configurations anticipated for free flight."
- It operates within the framework of the *National Plan for Civil Aviation Human Factors: An Initiative for Research and Application*, published in March 1995, with FAA, NASA, and DOD as signatories.
- It is consistent with the House Appropriations Committee's 1997 Department of Transportation Appropriations Bill, which cites human factors as "far and away the greatest cause of aviation accidents" and calls for a "high priority" on research into "human factors problems experienced by air traffic controllers and FAA maintenance personnel."

Accomplishments

The program has performed or sponsored the following research and resulting products:

- Sponsored the National Research Council's assessment of human factors issues in the air traffic control system. The Council's recent publication, *Flight to the Future - Human Factors in Air Traffic Control*, a product of this study,

contains a wealth of information, conclusions, and recommendations from this distinguished panel of aviation human factors experts is widely disseminated in the FAA.

- Published an extensive volume of information and advice on human factors issues in the design and evaluation of ATC systems and subsystems. To date, this book and its associated electronic checklist have been widely distributed within the FAA to ATS and integrated product team (IPT) customers for internal use.
- Supported FAA emphasis on the procurement of commercial-off-the-shelf (COTS) and non-developmental items (NDI) for application in ground-based NAS systems. This was done by creating and distributing a comprehensive reference book to aid in identifying and addressing human factors issues associated with the procurement, design, development, and testing of COTS/NDI systems.
- Validated the current air traffic controller pre-training screen selection instrument to ensure that it was both effective and free of any race, gender, or cultural bias.
- Completed development of en route Systematic Air Traffic Operations Research Initiative (SATORI), a high-fidelity research tool that uses routinely recorded ATC computer and voice data to re-create and display ATC operational incidents. SATORI has been transitioned to ATS, where it was procured for installation in all air route traffic control centers for use as a training tool and to study operational incidents.
- Conducted a human/system performance assessment of the departure sequencing engineering development model. Findings were briefed to ATS while the system was under consideration for national deployment.

- At the request of the Director, Air Traffic Services, conducted a human factors audit of the converging runway display aid installed at St. Louis Airport. This system is a decision support tool that helps terminal radar controllers efficiently space aircraft arriving on separate, converging runways.
- For the Director, Air Traffic Office of Plans and Requirements, conducted an assessment of the potential productivity gains that might be experienced by air traffic controllers in airport tower cabs due to the tower control computer complex that was then under development.
- For the Airway Facilities Operations Management Team, measured taskload and documented work processes of personnel at present maintenance control centers.

R&D Partnerships NASA, DOD, and FAA are cooperative partners in the development and execution of the *National Plan for Aviation Human Factors: An Initiative for Research and Application*. This document lays out a coherent national agenda for human factors research and provides the conceptual framework for the ATS Human Factors Program. Coordinated research efforts are conducted with NASA Ames in the areas of free flight and shift-work-induced fatigue and associated countermeasures. An inter-agency agreement with the U.S. Navy at the Naval Air Warfare Center is in place to facilitate collaborative research in areas of selection and training. Additionally, elements of the controller performance research project are conducted in concert with the U.S. Air Force at its Armstrong Laboratory. Grants are in place with universities to study human factors issues in air traffic management and automated systems. Internationally, research results on the development and validation of controller applicant selection methods are shared among project leaders in this program and their functional equivalents in Sweden and Denmark.

MAJOR ACTIVITIES AND ANTICIPATED FY 1998 ACCOMPLISHMENTS:

Selection and training.

- Developed and validated controller work team measures.
- Developed and transitioned prototype framework for implementing self-managed teams in the AF work environment.

Human performance assessment.

- Validated methodology for measuring air traffic controller performance.
- Developed strategies for human error prevention/mitigation in AF maintenance control centers.
- Identified impacts of alternative work schedules on controller performance.

Information management and display.

- Provided guidelines to enhance operator situation awareness.
- Provided recommendations regarding the optimal allocation of communications tasks between controllers and data linked systems.
- Enhanced capability to recreate operational incidents using recorded data from the display system replacement.

KEY FY 1999 PRODUCTS AND MILESTONES:

Selection and training.

- Identify controller skills and abilities required for future ATC systems.
- Develop and validate controller work team measures.

- Complete human factors analysis of air traffic control specialist (ATCS) roles and responsibilities in free flight.

Human performance and assessment.

- Provide validated ATCS performance measures.
- Develop and validate strategies for human error prevention/mitigation in AF maintenance control centers.
- Provide recommendations on work scheduling to reduce the impact of shift-induced operator fatigue.

Human-centered automation.

- Provide recommendations for display of complex data from multiple sources in air traffic management.

Information management and display.

- Provide guidelines to enhance operator situation awareness.
- Develop guidelines for air-to-air communications via data link in free flight.
- Develop guidelines for shared information displays in air-ground communications.

FY 1999 PROGRAM REQUEST:

The FY 1999 research program reflects a heightened emphasis on working with ATS to meet the pressing challenge of successfully fielding new technologies and procedures over the next several years. Research projects focus on providing timely information to answer critical human factors questions associated with these new systems and procedures (such as free flight) and thus

help to optimize human performance in the evolving and increasingly complex
NAS.

A08c Aeromedical Research

GOALS:

The FAA safety mission dictates that existent injury and death patterns in civilian flight misadventures be meticulously reviewed, that recommendations for protective equipment and procedures be developed, and that options be evaluated on behalf of FAA regulatory and medical certification staff charged with the proposal of safety regulations addressing all aircraft cabin occupants.

A concurrent mission is the identification of pilot, flight attendant, and passenger medical conditions that are incompatible with in-flight clinical and physiological demands on the occupant, both in the absence and presence of flight emergency conditions.

Intended Outcomes: The outcomes addressed by this research program are improved health, safety, and survivability of aircraft passengers and aircrews. This research program identifies human failure modes (physiological, psychological, clinical) both in uneventful flight, and during civil aircraft incidents and accidents. Formal recommendations for counteracting measures are derived from in-house research.

FAA is able to develop bioaeronautical guidelines, standards, and models for aircraft cabin equipment, procedures, and environments as a base for regulatory action to enhance appropriate human performance. By reviewing pilot medical and flight histories and information from accidents and incidents, new medical criteria, standards, and assessment/ certification procedures can be proposed to ensure full performance capability. By assessing flight attendant and passenger work, behavioral, and disease issues, guidelines for actions to improve the health and safety of the cabin occupant can be rationally proposed.

Agency Outputs:

The program has developed the following criteria for use in regulatory and certification processes:

- Quantitative bioengineering criteria to support aircraft seat and restraint system certification.
- Quantitative biomedical criteria to support protective breathing equipment and operational procedures certification.
- Quantitative biochemical and toxicological criteria supporting the use or certification of aircraft interior fire, smoke, and toxicity limits.
- Quantitative biomedical criteria to support flotation and onboard rescue equipment certification.
- Identification of medical/toxicological factors and human factors in aviation incidents and accidents.
- Recommendations for aircrew medical criteria, standards, and assessment/certification procedures.
- Quantitative data about the occupational health status of flight attendants to support regulatory oversight.
- Quantitative data about passenger behavior and health to support regulatory oversight.

Customer/Stakeholder Involvement: This program provides the primary bioaeronautical research (note: defined as the bioengineering, biomedicine, and biochemistry issues associated with safety and performance) called for in the *National Plan for Civil Aviation Human Factors* of 1995). (This plan committed to major deliverables referenced in the system safety goals of the FAA Strategic Plan of the following year.)

This program contributes significantly to the application of emerging technologies, as highlighted in the February 1996 FAA Aviation Safety Plan. The program is an integral participant and research provider under the FAA, Joint Aviation Authorities (JAA), and Transport Canada Aviation (TCA) Aircraft Cabin Safety Research Plan established in 1995 as a coordinated, living plan to maximize the cost-benefit of aircraft cabin safety research internationally.

International Civil Aviation Organization (ICAO) initiatives addressing the health of the aircraft occupant (crew and passenger) are developed under this program before final FAA recommendations are provided to ICAO. This program is the only research component of the FAA that can legally access confidential medical data about pilots for use in epidemiological research studies approved by FAA's institutional review board for use of human test subjects. Multi-year collaborative studies performed by the FAA and the National Institute for Occupational Safety and Health (NIOSH) into flight attendant and passenger symptomatology and diseases are funded by this budget item to satisfy the mandate placed by Congress upon the agencies in the FY 1994 Appropriation Act.

Accomplishments: Based on aeromedical research at the Civil Aeromedical Institute, the FAA will shortly issue an advanced notice of proposed rulemaking concerning the usage and design of child restraints on aircraft. The output of this program's research is permitting the FAA and National Highway Traffic Safety Administration to revise the testing requirements in Federal Motor Vehicle Safety Standard 213, which covers the design of child restraints for use in aircraft. A prototype aircraft seat insert dramatically improves the safety performance of conventional forward-facing child restraints used in aircraft. Quantitative data were provided regarding various prototypes of aircraft-specific child restraints being developed as commercial products targeted for airlines. Specialized quantitative crashworthiness assessments for new types of restraint systems continued, inclusive of a review of airbag systems proposed for in-flight applications.

Data is continuously provided to the research sponsor on the role of toxicological and clinical factors associated with each aircraft accident and significant incident. Current findings indicate that about one of six pilots fatally injured in a civilian aircraft accident shows evidence of using a prescription drug; one of four has taken an over-the-counter drug, one of 25 has ingested significant positive alcohol, and 1 of 20 is using a significant controlled dangerous substance. Long-term aviation forensic and epidemiological research has helped the FAA to identify human factor roles in accident/incident causation. Specialized clinical evaluations were applied to cases associated with decompression of the aircraft. Probable seizures and other factors indicative of the pilot's inability to perform were evaluated.

R&D Partnership: Several of these partnerships (e.g., FAA/JAA/TCA; FAA/NIOSH) have been cross-referenced in the Customer/Stakeholder Involvement and Accomplishments sections above.

In addition, in each of the program area output categories, the FAA maintains direct cooperative research processes with all the manufacturers responsible for the safety products enumerated (seats, restraint systems, oxygen masks, evacuation slides, etc.). FAA investigators also maintain memberships on every Society of Automotive Engineers committee addressing safety research conducted under this program. The agency maintains a liaison with the American Society of Heating, Refrigeration, and Air Conditioning Engineers committee addressing aircraft cabin air quality status and research. Besides the active involvement in the FAA/JAA/TCA process of oversight for safety research, participants in this program are represented on appropriate subgroups of organizations such as the Aerospace Medical Association, the Civil Aviation Medical Association, and the Professional Aeromedical Transport Association. Appropriate liaison with the military is maintained either through direct project collaboration (e.g., crashworthiness, eye injury from lasers) or through the more

global participation in the TriServices Aeromedical Research Panel or North Atlantic Treaty Organization aerospace medical advisory groups.

MAJOR ACTIVITIES AND ANTICIPATED FY 1998 ACCOMPLISHMENTS

The following program results have been achieved or are expected to be achieved in FY 1998:

- Performed epidemiological assessment of toxicology factors from fatal civilian aviation accidents.
- Developed guidelines to reduce inflight sudden/ subtle incapacitation.
- Evaluated autopsy data from fatal aviation accidents to determine protective equipment and design practices.
- Assessed flight attendant reproductive health hazards (congressionally-requested FAA-NIOSH study).
- Issued a report on the suitability of component tests for showing regulatory compliance with crashworthiness standards for aircraft.
- Published definitive evacuation escape slide angle and strength studies to minimize escape injuries and escape failures.
- Developed performance-based narrow- and wide-bodied aircraft cabin evacuation approval guidelines.
- Developed improved general aviation oxygen mask systems.
- Assessed operational hazards of inflight laser exposure.

KEY FY 1999 PRODUCTS AND MILESTONES

The following program results are being scheduled for FY 1999:

- Conduct epidemiological assessment of toxicology factors from fatal civilian aviation accidents.
- Compare toxicology findings at time of flight physical to post-accident data.
- Develop guidelines to reduce inflight sudden/ subtle incapacitation.
- Evaluate autopsy data from fatal aviation accidents to determine protective equipment and design practices.
- Report on guidelines for aircraft cabin occupant health maintenance.
- Development of model disease transmission via aerosols in an aircraft cabin environment.
- Develop performance-based narrow- and wide-bodied aircraft cabin evacuation approval guidelines.
- Evaluate the suitability of analytical modeling as a substitute for evacuation tests in the certification of new passenger aircraft.
- Develop improved oxygen mask systems.
- Evaluate the effect of refractive surgery on vision tasks in aviation.

FY 1999 PROGRAM REQUEST:

The Office of Aviation Medicine encounters complex medical decisions during the initial and follow-up medical assessments of airmen who request special medical issuances (e.g., cardiac conditions, neurological deficits, etc.) to permit their continued flying. The prospective epidemiological assessment of special issuance methodology and medical outcomes in the airman population is required to ensure that medical issuances do not result in unexpected or increased aircraft accident or incident rates.

Ongoing research projects will:

- Develop safer aircraft cabin evacuation approval guidelines and safer field applications under operational conditions.
- Reduce head, neck, and extremity injuries in aircraft crash environments.
- Evaluate trends in toxicology and clinical findings from all major civil aviation aircraft crashes.
- Develop guidelines for aircraft cabin crew and passenger environmental management.