081-110 Flight Deck, Aircraft Maintenance, Flight Deck/ATC System Integration Human Factors

Purpose:
This project will improve pilot, aircraft maintenance and inspection personnel performance and reduce the adverse effects of flightcrew, maintenance, and inspection errors through improved systems design, procedures, and training. An important element in this research is, when possible, applying existing knowledge of human capabilities and limitations to the flight deck and maintenance environments. Where existing knowledge is inadequate, this project will develop a better understanding of human performance factors. Statistics show that approximately 65 percent of all fatal civil air transport accidents and a higher proportion of general aviation (GA) accidents list human error as a probable cause. Since human errors contribute to the majority of aircraft accidents, a continuing program directed toward improved flight deck human engineering, identification and mitigation recommendations for work environment factors affecting flightcrew, maintenance, and inspection personnel performance, and enhanced individual and team training can pay for itself many times over by preventing a single accident. Properly human factored new technology developments and better pilot, maintainer, and inspector performance using existing technology will provide further benefits by increasing operational efficiency.

This project will also ensure new generation aircraft compatibility with the evolving automated NAS and decrease the frequency of flight deck/ATC communications errors through a total system approach. Flight deck/ATC integration raises unique considerations that are distinct from either ATC or flight deck issues and will be greatly affected by the technological improvements that are expected to occur simultaneously within both areas. Advanced computer aiding will facilitate controllers handling increased traffic but will also influence flightcrew performance and situational awareness. Data link, and ultimately satellite-based air traffic systems, have the potential to enhance system capacity, but will also influence controller and pilot workload in ways that are not currently understood. The transition to a free flight concept of operations accelerates the need to effectively address these issues. NAS safety and efficiency will be enhanced through system-wide analyses that integrate current and emerging airborne and ground subsystems.

Approach:
An important focus for the project is responding to relatively short-term requirements from sponsor organizations. A long-range goal is to develop the corporate human performance knowledge base that will scientifically support future rulemaking and safety programs. Analytical, laboratory, simulation, and field operational studies will be conducted in the following National Plan for Civil

Aviation Human Factors areas: human-centered automation, human performance assessment, selection and training, and information management and display. Information in data bases will be used to analyze the effects of selected human factors improvement methods, training, individual and operational stressors, and implementing increased automation. Organizational/managerial research will examine the influence of management practices, expectations, and norms as well as personnel practices, team operations, and organizational structure on flight deck and maintenance performance.Research reports, conferences, and direct assistance to operational organizations will be used to support operational evaluations and develop advisory circulars, technical standard orders, and Federal Aviation Regulations (FAR) changes. Participation in technical committees such as the Society of Automotive Engineers will assist with developing industry practices and standards.

An additional project focus is to enhance flight deck/ATC information transfer and management; decrease frequencies and consequences of flight deck/ATC errors; determine appropriate authority allocation between flight deck and ATC; and develop the required methods, tools, and guidelines for integrating NAS components into the flight deck/ATC environment. The goal is to reduce information transfer errors and minimize their impact when they occur.

Related Projects:
022-140 General Aviation and Vertical Flight Program, 082-110 Air Traffic Control/Airway Facilities Human Factors, and 083-110 Aeromedical Research, 025-110 National Simulation Capability (NSC), 031-110 Aeronautical Data Link Communications and Applications, and 065-110 Aging Aircraft.

University/Contractor Support:

Z

Z

Z

Products:

ZGuidelines for the human factors design, evaluation, and certification of advanced technology flight deck displays and control systems

ZResearch data base integrating information on pilot medical history, age, prior experience, airmanship history, and information on accidents and incidents

ZPilot and flightcrew behavioral coding techniques that can be used to assess flightcrew training program effectiveness

ZGuidelines for improved training programs in crew resource management, including aeronautical decisionmaking, team situational awareness, and leadership/followership strategies

D
Guidelines for selecting and training pilot instructors/evaluators

D
Guidelines for line-oriented flight training scenario development and assessment

D
Training guidelines for appropriate monitoring behaviors for pilot not flying

D
Guidelines for qualifying flight training devices and simulators for training/airman certification

D
Refined model advanced qualification program (AQP) for FAR Part 135 and Part 121 operators, and flight training centers, to include ab initio and recurrent crew training and assessment requirements

D
Specification of integrated navigation displays and memory aids that provide cost-effective options to GA pilots for reducing risk exposure and enhancing pilot performance

D
Human factors guidelines to establish policies for data link architectures and procedures

D
Human factors guidelines for developing, testing, and certifying interface designs of various computer/human interface applications

D
Operational and training recommendations to reduce pilot/controller verbal and digital communication errors

D
Revised selection and training criteria for certification and regulatory personnel

to properly match knowledge, skills, and abilities of pilots and controllers with changing performance requirements

D
Capability to assess human performance in a highly integrated future automation environment

D
Job task and training analyses for aircraft maintenance technicians

D
Human factors and ergonomics audit program in maintenance shops

D
Human factors guidelines to reduce automation-related errors in maintenance for government and industry

D
Intelligent tutoring systems in aircraft maintenance environment

D
Supporting data for FAR Parts 65 and 147 revisions

D
Human factors guidelines for industry/government communication, data exchange, and support infrastructure

D
Advanced documentation technology to provide rapid access to technical information

1996 Accomplishments:

D
Completed beta test for prototype automated performance measurement system (APMS) with two U.S. air carriers.

D
Developed model AQP for training centers to support regional air carrier involvement.

D
Determined requirements for the modification of a level 5 flight training device

to make it serve the same function as a level 7 flight training device.

D
Developed guidelines for effective crew performance debriefing in line-oriented flight training.

D
Identified flight crew leadership/followership skills for training course development.

- Provided educational outreach to the aviation community through the NASA/FAA fatigue countermeasures training module.
- Developed the fatigue crew resource management education module.
- Prototyped the first computer model of fatigue impact on work scheduling.
- Completed research linking visual strategies correlated to fatigue.

D
Specified minimum requirements for electronic chart formats for use in terminal area procedures.

D
Evaluated the effectiveness of alternative course-deviation-indicator display formats for minimizing flight technical errors in terminal operations.

D
Completed NTSB database analysis of controlled flight into terrain accidents for ground collision avoidance system alerting displays.

D
Developed pilot performance data through flight simulation for use in establishing certification standards for autonavigation and control systems.

D
Identified flight crew procedural recommendations for loss of clearance information in the data link environment.

D
Completed assessment of data link timing and procedural constraints in different airspace types (enroute and terminal).

D
Identified relevant research findings in the field of data link human factors that will correspond to human factors issues in the free flight domain.

D
Developed concept guidelines on maintenance technician resource management.

D
Supported Sandia Laboratories visual inspection using previously developed visual inspection and NDI guidelines.

D
Developed and evaluated work environment influence on technician performance.

D
Implemented and evaluated human factors and ergonomics program in maintenance shops.

D
Evaluated situational awareness training needs related to maintenance environments.

D
Updated aircraft maintenance Human Factors Guide.

D
Developed electronic version of aircraft maintenance human factors issues guidebook.

- Developed a video, computer based training, and printed training modules for the general aviation personal minimums checklist.

- Developed training scenarios for use in the small aircraft flight environment (SAFE) training system.

- Developed a computer based training module for decision training of pilots of mid-altitude, high performance aircraft.

1997 Projected Accomplishments:

- Complete evaluation of general aviation head up display design.

- Identify comntrol/display requirements for general aviation aircraft in a free flight environment with emphasis on separation assurance.

- Complete evaluation of terrain alert and escape instruction formats for ground collision avoidance system displays.

- Refine and field test the human fatigue model.

- Exercise the first fatigue risk/exposure diagnostic tools in operational environments.

D
Evaluate data link communications for air-air and air-ground communications related to transgression of free flight zones.

- Assess the impact of data link vs. voice on the size and timing of free flight alert zones.

- Refine model AQP for FAR Part 135 and Part 121 operators.

- Develop a draft AC120-54 revision on AQP for the approval process.

- Develop methods to analyze AQP crew performance data.

- Develop preliminary guidelines for aviation team training focusing on crew decisionmaking, situational awareness, and leadership/followership processes.

- Complete development of the aero model, motion, and visual criteria for validating level B simulator.

- Update aircraft maintenance human factors issues guidebook.

- Implement and evaluate maintenance research management prototype training in air carrier operations.

- Develop a prototype expert system for integrated training, job aiding, and information retrieval in the aircraft maintenance environment.

- Develop a draft advisory circular on aircrew training for automated flight deck environments.

- Develop a weather-related decision training module for general aviation pilots.

- Validate general aviation training modules for personal minimums and mid-altitude decision making.

Planned Activities:

Selection and Training
In 1998, AQP research will continue on a refined model AQP for Part 121 and 135 operators with completion expected in 2000.

In 1998, research will continue to refine the preliminary aviation team training guidelines and produce the final guidelines. This research will also study the decisionmaking process among dispatchers, air traffic controllers, and pilots. Research will continue through 1999 and will address free flight implications for systematic decisionmaking.

From 1998 through 2000, systematic research efforts will quantify the performance transfer for level 1-7 flight training devices, and level A-D certification/training recommendations will be completed. This research is needed to establish the allowable credit for training and checking tasks when using a flight training device in place of actual aircraft flight training and testing. This specifically addresses critical needs of commuter airlines.

In 1998, guidelines will continue to be developed and evaluated on technician resource management and situational awareness. Results from these guidelines will be made available to regulatory organizations and industry by 1998.

Human Performance
In 1998, development work will continue on an APMS for evaluating training program effectiveness. An advanced prototype will be completed in 1998, followed by operational evaluation and validation leading to advanced APMS specifications for airline use in 2000.

From 1998 through 2002, the fatigue program efforts will focus on validation the computerfatigue model, utilizing fatigue risk/diagnostic tools to describe the different aviation environments, and initiaiting the fielding of future technological solutions for smarter system interfaces.

In 1998, research will continue on producing objective data on air crew performance. This information will be used to produce certification guidelines and data to support regulation decisionmaking relative to aircraft design for the general aviation community.

From 1998-2005, updates to the aviation maintenance human factors issues guidebook will be published in an electronic format.

From 1998- 2000 research will continue to identify and rectify error facilitators in the aircraft maintenance workplace.

Human-Centered Automation

In 1998, an expert system will be completed for integrated training/job aiding/information retrieval in the aviation maintenance environment.

From 1998-2001 research will continue to identify and mitigate flight deck automation related crew performance impacts.

Information Management and Display

In 1998, general aviation research will continue to collect scientific data to aid in identifying equipment design and pilot training initiatives. Human factors guidelines will be developed to assess cockpit integration of advanced navigation and alerting systems and to assess the effects of head-up displays in GA cockpits. Work will continue on developing data to assess the effects of pilot aging on performance and to determine task-based requirements for transitioning GA pilots into a free flight airspace environment.

From 1998 through 2000, high fidelity simulation research will continue on relevant GA problems to obtain objective, scientifically derived data to aid in identifying affordable options for reducing GA pilot risk exposure and the number of incidents and accidents in the general aviation community. Using flight simulation, guideline data will be developed for application to the cockpit design of the advanced general aviation transport experiments aircraft.

From 1998 through 2000, work will continue to ensure that as automation and data link systems come on-line, the human operator will obtain the proper information at the appropriate time. In 1998, recommendations will be made for cockpit displays addressing transgression of free flight alert zones. Also in 1998, recommendations will be made on procedures for communication of aircraft intent using data link, voice, or both in a free flight environment.

In 1998, several years worth of research will result in the development of human factors design guidelines for ground collision avoidance systems.

082-110 Air Traffic Services Human Factors

Purpose:

Statistically human error has been identified as a causative factor in over 65 percent of aviation accidents. The FAA has recognized the fact that proper consideration of human factors is central to the design, integration, and evaluation of effective systems; procedures; selection instruments; and training. This project will enhance the efficiency of the NAS by developing scientifically validated information that focuses on improving the performance and productivity of the human operator in the Air Traffic (AT) and Airway Facilities (AF) organizations.

The introduction of new systems and operational concepts such as centralized NAS maintenance monitoring or free flight will also result in unprecedented, and unavoidable, changes in organizational culture. This project will help to optimize human systems in the light of technological and organizational change and provide information necessary to make informed decision regarding the best methods to implement strategic planning initiatives and achieve organizational goals.

Approach:

The Air Traffic Services (ATS) Human Factors project operates in consonance with other FAA strategic and program plans as well as the National Plan for Civil Aviation Human Factors.

Personnel selection and training are of vital concern to the ATS organization. Air traffic controllers and NAS technical personnel comprise the overwhelming majority of FAA employees. Both groups will experience dramatic change in the future. The AF workforce is projected to decrease significantly and to be supplemented by automated systems and centralized monitoring. A majority of today's air traffic controllers will approach retirement age by the year 2002. Validated, performance-based selection instruments are needed in time to meet the projected demand for replacements.

New technologies are rapidly being introduced into the NAS environment in response to the need for increased efficiency and reliability. These technologies will be catalysts for change in the roles of humans in the system. As the NAS evolves, alterations in the mixture of knowledges, skills, and abilities required of future operations personnel are virtually inevitable. This project will assess technological change by examining current NAS projects, operations planning documents and philosophy and then use this information to determine what skills are likely to be needed. Subsequent findings will be evaluated using simulation. Knowledge of anticipated skill requirements will enable the FAA to effectively accommodate evolutionary changes by developing personnel systems closely integrated with, and reflecting the operational requirements of future, highly automated ATC systems.

Assessing the impact of new technologies or procedures will require reliable methods of measuring operator/system performance. This project will develop and validate metrics that are sensitive to human performance, workload, and decision making in the present, and through simulation, future NAS systems. These performance-based, feedback tools

will provide FAA management with the capability to objectively predict the impact of change. Analyses of organizational and environmental factors affecting performance will also provide data leading to innovative methods for improving safety and productivity through the reduction/mitigation of system and fatigue induced human error.

Human perceptual capabilities and limitations as they relate to the design and integration of AT and AF equipment and systems will be explored. Issues such as optimized computer/human interfaces (CHI) will be tested and validated through simulation. The potential impact of automation on work activities, performance, and productivity will be studied and appropriate guidelines will be developed to facilitate the introduction of new technologies. Reference information on human factors that can be applied in formulating future operational requirements will be developed. Recommendations to help system planners to identify and avoid design deficiencies that have the potential to induce operator error will be produced.

Assessing the impact of automation on system operators will yield insight into the complex interrelationship between man and machine. Measures of situation awareness will be developed and validated through simulation. Studies will be conducted to determine the optimal allocation of tasks between humans and technology. Recommendations for the design of human-centered automated systems will be developed. These guidelines will aid in the design of automation that fully supports the role of the operator and thus minimizes the probability of human error.

Related Projects:
081-110 Flight Deck, Aircraft Maintenance, FlightDeck/ATC Integration Human Factors Human Factors, 083-110 Aeromedical Research, and M#07 National Infrastructure Management System (NIMS).

University/Contractor Support:

Embry-Riddle Aeronautical University, Ohio University, Ohio State University, University of Minnesota, Texas Tech University, Oklahoma University, Volpe National Transportation Systems Center, McManis Associates Inc., JIL Systems, NYMA Inc., NASA, FAA Civil Aeromedical Institute, FAA Technical Center

Products

Qualitative and quantitative human factors reference information to assist in designing, integrating, and evaluating AT and AF systems that facilitate task performance, reduce workload, and promote productivity

Analysis tools and standards for assessing/predicting operator work activity and performance

Guidelines and models for optimally allocating operational functions and tasks to operators and their equipment

Real-time simulations, rapid prototyping, computational models, and reference data that support FAA specifications, acquisitions, and tests for improving NAS equipment and procedures

Capability to reconstruct en route operational errors and incidents

Tools and reference information for improved controller selection and training programs

Effective countermeasures to combat fatigue associated with rotating shift work

Analyses that characterize miscommunications in the ATC system and offer recommendations for corrective action

FY96 Accomplishments

Validation study of generic sectors (TRACON and Enroute) as research tools to evaluate performance metrics

"Human Factors in the Design and Evaluation of ATC Systems" - a guide that presents human factors issues that should be considered in the design and evaluation of ATC systems and subsystems.

"Guidelines for Developing Symbols within Airway Facilities" - a guide to the design and application of symbology for use in centralized control centers

"Human Factors Design Guide for Acquisition of COTS and NDI Developmental Systems" - a comprehensive reference tool for persons concerned with human factors issues in AF acquisitions

TRACON version of Systematic Air Traffic Operations and Research Initiative (SATORI) that extends SATORI's incident recreation capability to the terminal environment

Evaluations of, and recommendations to remedy, potential human factors issues in the Air Traffic Control System Command Center

Analyses of pilot-controller communications issues.

Organizational effectiveness study of AF work flow process and prototype event ticketing implementation plan

FY97 Projected Accomplishments

An assessment of the application of human factors design principles in the development and fielding of automated ATC systems

Human factors quidelines on the application of new technologies in centralized AF control facilities

A prototype training intervention product designed to enhance team work effectiveness in air traffic control towers

Suggested strategies to reduce controller reliance on flight progress strips in the enroute environment of the future (DSR)

Guidelines for the implementation of self-managed teams in Airway Facilities

Initial guidelines for color coding information on system displays

A prototype training intervention module to teach effective team decision making skills in the control tower environment

Advanced simulation capability to investigate potential sources of human error in the AF work environment of the future

SATORI software enhancements that provide the capability to simulate and study human factors issues inherent in alternate separation assurance concepts such as free flight

Planned Activities:

Selection and Training

In 1998, research will continue on validating performance-based selection instruments. An initial predictive validation study for AF technicians interpersonal and teamwork predictors will be completed. New technologies will be explored for potential application in selection and training. In 1999, guidelines for enroute controller team composition, training interventions, and performance metrics will be completed. From 1998 to 2001 research will also be conducted to identify appropriate selection criteria for future air traffic controllers and NAS technicians based upon the roles they will assume in the next-generation, highly automated ATC system. These criteria along with associated measurement techniques, will be developed and validated through 2003. (AT/AF)

Human Performance

In 1998, research into air traffic controller performance measurement will continue. Tools such as the generic sector previously developed under the auspices of this project will be applied to this effort. In 1998, the first measurement tools will be available to support human/system performance baselining. From 1998 to 2000, performance metrics will be further refined and published in handbook form. (AT)

In 1998, the effectiveness of previously developed countermeasures to rotating shift-induced fatigue will be evaluated in field settings. Operator performance will be studied as it relates to the effects of shift work.. Recommendations for optimal shift schedules will be published and made available to FAA organizations. (AT/AF)

In 1998, new applications for the SATORI tool will be explored. SATORI will be used to develop measures of TRACON personnel taskload and performance. Emphasis will be placed on identifying root causes of human error. In 1999, intervention strategies will be developed to help reduce the occurrence of operational errors. (AT)

Research into human error in Airway Facilities will continue in 1988. Particular emphasis will be placed on the future AF work environment. Strategies for error prevention and mitigation will be developed in 1999. (AF)

Human Centered Automation

In 1998, research will be initiated to determine the most appropriate role for human operators in the ATS system of the future. This project is based on the premise that automated equipment and human operators are integral parts of a whole system. From 1998 to 2003, human-in-the-loop analyses will be conducted. Research findings will be used with next-generation ATS system projections to develop initial human/computer role relationships by 2005. From 2006 to 2008 these relationships will be tested, evaluated, and modified. Final human factors design specifications for next-generation ATC automation systems will be completed in 2009. (AT/AF)

Research into human factors issues in the evolving concept of free flight will continue. Recommendations to facilitate the implementation of free flight from the human perspective will be made available on a yearly basis at least through 2001. (AT)

Information Management and Display

In 1998 studies into the appropriate use of color in NAS system displays will expand. Future efforts will investigate the most effective application of color in system displays. Emphasis will be placed on determining ways that color can be employed to depict an ever increasing volume and variety of information in a manner that enhances operator situation awareness and reduces the incidence of human error triggered by information overload. Project reports will be produced in 1999 and 2000. (AT/AF)

Work will continue on developing methods to measure enroute air traffic controllers' situation awareness (SA). These measures will be available to evaluate SA in alternate separation assurance concepts such as free flight or as part of the testing procedure for proposed new equipment or procedures. Recommendations will be offered regarding information requirements for maintaining SA in 1998 . (AT)