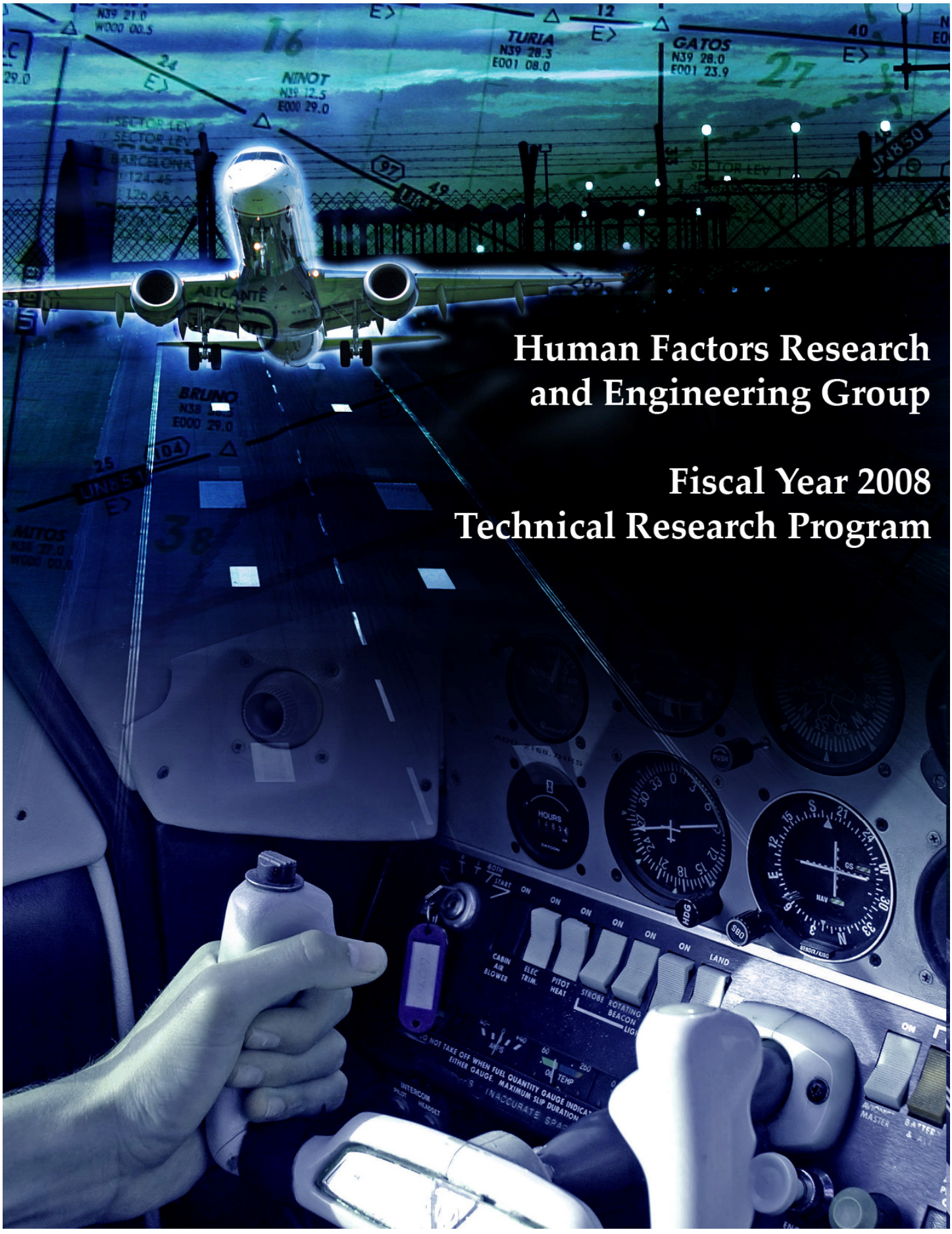

Human Factors Research and Engineering Group

Fiscal Year 2008 Technical Research Program

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Flight Deck/Aviation Maintenance/System Integration Human Factors

Program Description

The Flight Deck/Maintenance/System Integration Human Factors Program (Flight Deck) is managed by Dr. Tom McCloy. The program includes General Aviation, Air Transportation Human Factors, Flight Technologies and Procedures, Vertical Flight, Unmanned Aerospace Systems, and Aviation Maintenance. Research in these areas helps achieve FAA's Flight Plan goals for increased safety and greater capacity by:

- Developing more effective methods for pilot, inspector, and maintenance technician training

- Enhancing the understanding and application of error management strategies in flight and maintenance operations

- Increasing human factors considerations in certifying new aircraft and in equipment design and modification

- Improving pilot, inspector, and maintenance technician task performance

- Developing methodologies to identify and mitigate risk factors in automation-related operator errors

- Developing requirements, knowledge, guidance, and standards for design, certification, and use of automation-based technologies, tools, and support systems

- Addressing human performance and human-system performance requirements associated with transitioning from 2015 to 2025 NextGen capabilities.

The Flight Deck program provides the research foundation for FAA guidelines, handbooks, advisory circulars, rules, and regulations that help to ensure the safety and efficiency of aircraft operations. It also develops human performance information that the agency provides to the aviation industry for use in designing and operating aircraft and training pilots and maintenance personnel.

Flight Deck researchers work directly with their colleagues in the FAA, other government agencies, academia, and industry to support research and development programs and initiatives such as NASA's Aviation Safety Program, the FAA Voluntary Safety Program, the FAA/Industry Safer Skies Initiative, and the Congressionally-directed FAA Research, Engineering and

Development Advisory Committee. Flight Deck researchers also collaborate with industry and other government programs through Joint Safety Analysis Teams and Joint Safety Implementation Teams, the DoD Human Factors Engineering Technical Advisory Group, Aviation Maintenance industry partners, the Society of Automotive Engineers, and via cooperative research agreements with universities and other research organizations.

Listed below are descriptions of FY 2008 Flight Deck research activities.

General Aviation

Redesigning Weather-Related Training and Testing of General Aviation Pilots

Summary: Researchers at the University of Wisconsin developed advanced flight simulation scenarios, based on known visual flight rules flight into instrument meteorological conditions accident profiles, to empirically train and evaluate general aviation (GA) pilot application of basic weather knowledge and decision-making skills. These simulation scenarios will provide an innovative tool for improving pilot weather-related decision-making and reducing fatal GA accidents.

Description: Weather-related accidents, particularly accidents due to visual flight rules (VFR) flight into instrument meteorological conditions (IMC), are associated with the highest fatality rate within general aviation (GA). Specifically, the fatality rate of VFR into IMC accidents is approximately 80% compared to roughly 19% for other types of GA accidents. Previous research at the University of Wisconsin indicates that accidents related to VFR flight into IMC often involve inexperienced pilots who lack the skills to properly plan VFR cross-country flights, effectively assess changes in weather during flight, and appropriately evaluate risks of continuing flight into adverse weather or safely avoid/exit IMC when it is encountered. These findings point to the need to improve weather-related training, as well as the manner in which weather-knowledge and decision-making skills are tested and evaluated.

To address this problem, researchers are exploring better ways to train and test weather-related decision making among GA pilots. They are developing advanced flight simulation scenarios, based on known VFR flight into IMC accident profiles, to empirically train and evaluate the skills of GA pilots in applying basic weather knowledge in "real time", during dynamic simulated flight. These simulation scenarios will provide an innovative tool for systematically training and assessing pilot weather-related decision making skills, as well as evaluating the effectiveness of new intervention programs targeted at reducing accidents associated with VFR flight into IMC.

The results of this project will provide empirical data to inform FAA decision-makers

about how best to redesign flight training, testing, and currency requirements in an efficacious yet cost-effective manner. This project also addresses the goal of the FAA to reduce GA fatalities and the AFS 800 RE&D requirement associated with the development of Advanced Simulator Weather Simulations.

Assessment of Current Weather-Related Training Aids

Summary: CAMI personnel selected a sample of video weather training products believed likely to influence general aviation (GA) pilot decision-making when planning for operations in the vicinity of developing weather, or operating in the vicinity of developing weather conditions that might impact a flight. Fifty GA pilots were invited to CAMI to assess the impact of selected programs on their weather knowledge and pre-flight and flight behavior. A report summarizing findings will be delivered to the sponsor this year.

Description: Adverse weather continues to be one of the leading causes of general aviation (GA) pilot fatalities in the U.S. This persists in spite of a large effort by the FAA and other organizations to educate GA pilots on the hazards associated with weather. Unfortunately, many of the educational programs involve training (either through classroom lectures, on-line instructional programs, or CD-ROMs) whose effectiveness has not been scientifically evaluated for its practical application.

CAMI researchers reviewed available weather training programs and assessed the knowledge and behavioral impact of exposure based upon a sample of these programs. An inventory of weather training packages provided by FAA and other organizations that address the basics of weather theory and target leading causes of weather accidents was developed. The research team selected a sample of video weather training products believed likely to influence GA pilot decision-making when planning for operations in the vicinity of developing weather conditions, or operating in the vicinity of developing weather conditions that might impact a flight. Fifty GA pilots were invited to CAMI to assess the impact of selected programs on their weather knowledge and flight behavior.

Pilot baseline weather knowledge was measured with a computerized pretest. They were exposed to either one of two weather training videos (the Experimental Groups) or to a non-weather related video (the Control Group). Pilots' weather knowledge was then retested with an alternate, matched-difficulty form of the knowledge test, to measure the effect of the training products. All pilots engaged in a simulated flight through weather sufficiently challenging to elicit variation in pilot responses. These responses ranged from quick diversions to alternate airports, all the way to full completion of the assigned flight. The experiment assessed differences on a large number of pre-flight and flight behaviors (e.g., length of weather preflight briefing, total flight time, penetration distance into the weather, number of in-flight weather updates requested, ground clearance, cloud clearance, etc). Finally, weather knowledge and flight behavior were again assessed after an elapsed time interval of approximately three months, to test retention of training.

Analysis is underway, and a draft report summarizing findings will be delivered to the sponsor in September. Final reports will be provided in FY09.

A New Approach to Aviation Accident/Incident Prevention/Mitigation

Summary: To address the human component of aviation safety, many in the field have embraced a system safety approach. Previous efforts have targeted hazard identification and prioritization using the Human Factors Analysis and Classification System (HFACS). The next step in the system safety process is to identify and assess potential interventions. One tool that may prove useful is the Human Factors Intervention Matrix (HFIX). To assess the utility of HFIX, the current research employed HFIX to address visual flight rules (VFR) flight into instrument meteorological conditions (IMC). Several new interventions surfaced: increasing oversight for equipment and training, ensuring that the FAA allocates resources for pilots to increase proficiency and awareness, and the installation of weather radar in aircraft. A technical report linking together previous studies using HFACS with those employing HFIX within a system safety model has been submitted and is currently under revision.

Description: To address the human component of aviation safety, many in the field have embraced a system safety approach to identify and assess potential interventions. One tool that may prove useful is the Human Factors Intervention Matrix (HFIX). HFIX includes five broad areas around which interventions can be developed: 1) organizational, 2) human, 3) technology, 4) task, and 5) environment. To assess the utility of HFIX, the current research employed HFIX to address visual flight rules (VFR) flight into instrument meteorological conditions (IMC). Five pilot experts were recruited for the intervention prioritization part of the HFIX process. The pilot experts were instructed to rate 136 interventions on a five-point Likert scale with ”one” representing “low” or “poor” and ”five” representing “high” or “excellent” on each of four dimensions: *1) effectiveness* (i.e., What is the likelihood that it will reduce general aviation accidents?); 2) *cost* (i.e., Can the organization afford the intervention?); 3) *feasibility* (i.e., How easy will it be to implement the intervention?); and 4) *acceptability* (i.e., Will the aviation community accept the proposed intervention?). When we focused on the effectiveness dimension, the top intervention for reducing VFR-IMC was standardizing flight training that covers VFR flight into IMC. However, several new interventions surfaced: increasing oversight for equipment and training, ensuring that the FAA allocates resources for pilots to increase proficiency and awareness, and the installation of weather radar in aircraft. A technical report linking together previous studies using HFACS with those employing HFIX within a system safety model has been submitted and is currently under revision.

Developing Proactive Methods for GA Data Collection

Summary: Though the FAA, airlines, and their employee representatives have undertaken more proactive approaches to identify risk such as through Flight Operations Quality Assurance data and internal safety reports, general aviation (GA) safety remains

driven primarily by accident investigation. This project explored whether data could be captured for GA, enabling more proactive approaches to risk management. Twenty-one pilots were interviewed regarding their experiences during a flight assist, emergency, or weather encounter. Circumstances that preceded the pilot events were reviewed and several sources of weather products were mentioned by the pilots. The synchronicity of these products with real-time weather, reliability, and standardization should be addressed.

Description: Though the FAA, airlines, and their employee representatives have undertaken more proactive approaches to identify risk such as through Flight Operational Quality Assurance (FOQA) data and internal safety reports, general aviation (GA) safety remains driven primarily by accident investigation. This project explores whether data could be captured for GA, enabling more proactive approaches to risk management.

AFS-800 provided CAMI personnel with information concerning over 150 events. After reviewing the events, CAMI determined that approximately 90 events fit the profile of interest. CAMI contacted approximately 45 Flight Standards District Offices and 125 Aviation Safety Inspectors. As a result of these efforts, twenty-one pilots were interviewed regarding their experiences during a flight assist, emergency, or weather encounter.

Circumstances that preceded the pilot events varied from a failure to appreciate and/or understand the weather, underlying motivating factors that encouraged the pilot to press-on, and relying on incomplete or conflicting weather information. Previous Human Factors Analysis and Classification System analyses of weather accidents lacked the richness that these cases provide. The majority of pilots were instrument rated, which may reflect their exposure to these types of events rather than a causal factor for the event. Several sources of weather products were mentioned. The synchronicity of these products with real-time weather, reliability, and standardization should be addressed.

Sponsors were provided a mid-year briefing. An interview protocol was developed that could be used by Flight Standards Aviation Safety Inspectors. A draft summary of all interviews is scheduled for delivery to the sponsors by the end of September 2008.

Maintenance of HFACS Database for Aviation Community Research

Summary: A technical report summarizing general aviation accident causal factors that were classified with Human Factors Analysis and Classification System (HFACS) categories and traditional demographic data was published. Accident data coding and analyses have been completed. Discussions were held with the Aviation Safety Information Analysis and Sharing program office about transitioning the on-line database to their network server to foster sharing and centralizing data among the FAA workforce.

Description: The Human Factors Analysis and Classification System (HFACS) is a theoretically based tool for investigating and analyzing human error associated with

accidents. Previous research has shown that HFACS can be reliably used to identify general trends in human factors associated with commercial and general aviation (GA) accidents. This project supports development of a larger civil aviation safety program whose ultimate goal is to reduce the aviation accident rate through systematic, data-driven investment strategies. An online system will provide access to appropriate FAA officials and committees for needed analyses.

Accident data utilized in this task were downloaded via records maintained by the National Transportation Safety Board (NTSB). After several hours of training, pilot and mechanic subject matter experts (SMEs) coded finalized NTSB accidents via the online HFACS system. SMEs were randomly assigned accidents so that two separate SMEs independently analyzed each accident. After the SMEs assigned their initial codes, the two independent codes were compared. Where disagreements existed, the corresponding SMEs were instructed to reconcile their differences, and the consensus code was included for further analysis.

The database contains nearly 34,000 U.S. accidents for the period 1990-2006 across all types of operations. Over 28,500 have been coded for human error as identified by the NTSB. More than 25,000 accidents are Title 14, Code of Federal Regulations (CFR) GA part 91 accidents. Nearly 1,500 accidents in the database are commercial Title 14, CFR Part 121 and Part 135.

CAMI personnel have conducted detailed analysis of each of the different error forms (e.g., decision errors, skill-based errors, perceptual errors, violations, etc.), and ultra-fine grained analysis on selected error forms. Researchers made the online database available to FAA personnel as requested. The on-line database has over 20 active search user accounts.

Accident data coding and analyses have been completed. Discussions were held with the Aviation Safety Information Analysis and Sharing (ASIAS) program office about transitioning the on-line database to their network server to foster the sharing and centralizing data among the FAA workforce. ASIAS has agreed to assume the database in coming years.

Monitoring Pilot, Designee, and Inspector Perceptions of FAA Services

Summary: A variety of aviation safety functions require feedback from constituents to provide assessments of both FAA services and the adequacy of policy and regulation. Some types of feedback are further required by statute, such as the Government Performance Results Act (GPRA). CAMI surveyed regulated populations (e.g., general aviation - GA pilots) and designees (e.g., Aviation Medical Examiners - AMEs) to evaluate satisfaction with FAA services and the adequacy of policy and regulation. The majority of pilots indicated that the examiner who conducted their practical was prepared and organized to a considerable or great extent. Results from the AME survey and the Aerospace Medical Certification Subsystem (AMCS) pilot survey are being analyzed.

Description: *P-ASEL Survey* – The P-ASEL survey is an annual survey designed to collect data from newly certified GA Private Pilots with an Airplane-Single-Engine-Land Rating. The survey asks pilots about their experience with Designated Pilot Examiners (DPE) and the practical exam. The 2007 survey was distributed to 5,072 pilots from July 2007 to January 2008. Responses from 1,475 pilots met the criteria for inclusion (29% response rate). Returned surveys were screened to include only pilots who were tested by a DPE, Aviation Safety Inspector (ASI), or both DPE and a final phase check, who reported no previous P-ASEL practical test failures, and who indicated that their most recent practical test was not a re-test. The 2007 sample included pilots whose most recent practical test was a complete test or a partial test. Nearly all pilots indicated that they obtained a copy of the FAA PTS and used it to review the requirements for their practical test. The majority of pilots indicated that the examiner who conducted their practical was prepared and organized to a considerable or great extent. A complete item report comparing the 2006 and 2007 P-ASEL was delivered to sponsors. Distribution for the 2008 survey began in April 2008 and will continue until 5000 surveys have been sent (~ October 2008). Currently, 2,854 surveys have been distributed.

AME Survey – The AME survey is a biennial survey designed to collect data from examiners about their satisfaction with the aeromedical certification services provided by the FAA. The survey complies with the requirements set forth by Executive Order No. 12862, "Setting Customer Service Standards," and the Government Performance and Results Act of 1993 (GPRA) to assess customer satisfaction with services provided by or on behalf of federal agencies. The 2008 AME survey was distributed to 3,439 AMEs via e-mail and postal mail. There were 1,226 responses that met the criteria for inclusion (36% response rate). Data is currently being analyzed and will be reported to sponsors in late 2008.

AMCS Pilot Survey - The Aerospace Medical Certification Subsystem (AMCS) pilot survey is a biennial survey designed to collect data from civil airmen about their satisfaction with the aerospace medical certification services provided by the FAA. The survey is administered to assess the services provided to pilots by AMEs and the Office of Aerospace Medicine. For each administration, the survey has been distributed to 16,000 pilots. The pilots were selected in a random and stratified manner. Pilots were randomly and proportionately sampled by class (1, 2, 3) and status of medical (denied, issued, deferred). The current survey was administered in July 2008. To date, 2,878 responses have been received. Reminder postcards are being sent and the survey is scheduled to close September 30, 2008. Results from the 2008 AMCS Pilot Survey will be analyzed and compared to previous administrations.

Air Transportation Human Factors

A Situational Approach to Flight Crew Training

Summary: Although the need for integrated crew resource management (CRM) and technical training has long been recognized, the means by which this integration should be accomplished remains illusive. This project has the objective of creating a conceptual framework within which CRM and technical contributions to the flying job can be meaningfully positioned.

Description: The first phase of this project involved creating a methodology and software tool (Proteus) for creating flight crew training programs within the framework of the FAA's visionary Advanced Qualification Program (AQP). This work involved enhancing the AQP methodology to support a comprehensive and concrete approach to developing training that achieves the broad range of goals encompassed by AQP. The second phase of the project explored the conceptual foundations of CRM and AQP in order to support a fresh look at how training should be designed. As a result of this work, researchers at Battelle Memorial Institute concluded that the creation of integrated training requires a situational orientation that satisfies four issues:

- A "flight crew's eye view" of the flying job that reflects the meaning a situation has for the crew.
- A model of how crews perform in the operational environment that embodies integrated skill use.
- A methodology for creating training opportunities that target key skills.
- A strategy for designing training curricula that produce crews capable of effectively performing in the range of situations they could experience during line operations.

This new approach to conceptualizing CRM and AQP produced a number of new assumptions about how training should be conducted in order to effectively embody this situational orientation. Applying this approach to Battelle's enhanced AQP methodology suggested some opportunities for improving the methodology that would both improve the training produced using the methodology, and also bring it into alignment with our conceptual framework.

Three major categories of enhancements were made to the Proteus methodology. First, the task analysis methodology was supplemented to support simpler identification of themes. Enhancements took the form of additional structure that helps to guide the performance of the task analysis towards the identification of a core set of themes that define proficiency for each task. Arguably the most significant change concerns how proficiency objectives are defined. In the first-generation Proteus methodology, TPOs and SPOs closely resemble the tasks from which they are derived. This approach makes sense only if proficiency is defined in a maneuver-based framework. We argue that proficiency should be defined in terms of themes, which means that proficiency objectives must necessarily become themes which are more generic than was the case when they were used solely for creating events. Finally, modifications were made to the

event methodology based upon the need to show how events are defined from theme-like proficiency objectives. The relationship between proficiency themes and those used in the creation of events was clarified.

Improving Pilots' Visual Approaches through Perceptual Training

Summary: In collaboration with a large U.S. regional airline and together with researchers from George Mason University, University of Central Florida scientists are investigating the skills pilots need in order to effectively conduct a visual approach. The purpose of this research is to identify skills, develop prototype training, and develop performance metrics that will improve training and evaluation of pilots on visual approach tasks. Through this research program and subsequent training developments, we expect to impact current pilot training protocols by reducing initial operating experience time and improving visual profiles.

Description: The visual approach phase of flight continually poses a major challenge for junior airline pilots. Airlines have reported that new hires with low flight hours experience difficulty in "managing visual approaches in line operations." The difficulty can be attributed to the often non-standard nature of the approaches and because it is difficult to effectively model the visual and kinesthetic cues for visual approaches in today's flight simulators. Human factors researchers are investigating the skills pilots need in order to effectively conduct a visual approach, and developing training and performance metrics that will improve training and evaluation of pilots on visual approach tasks. Through this research program and subsequent training developments, we expect to impact current pilot training protocol by reducing IOE time and improving visual profiles.

The current focus is on training perceptual skills using a discrimination task that involves making judgments between two static visual approach images that are manipulated with fractional changes in glide slope, distance, runway orientation, and runway layout. The goal of this research is to improve a pilot's ability to attend to critical visual cues in the environment for distance estimation. Our initial study confirmed that non critical cues are used when making discriminations from a non-pilot population. These findings confirm that inexperienced pilots use non-critical cues when making visual approach distance estimations. We also expect to find that through discrimination training, performance will improve on visual approach tasks.

Analysis of Pilot Procedures and Practices for Automated Flight Decks

Summary: The goal of this research program at George Mason University is to assess current issues with automated systems on the flight deck and develop potential training solutions to problems generated by these new systems. This work addresses the FAA requirement to approve new systems for use on the flight deck and approve the training required of commercial pilots. The result will be methods that can be used to develop more effective training to improve the safety of the entire aviation system.

Description: Automation has introduced changes to the forms of aircrew interaction in the cockpit. Although designers hoped that these changes would reduce errors, evidence suggests that this has not been the case. This leads to the question of how we might improve the performance of crews using automated cockpit systems. One approach is to design training and cockpit procedures with automated systems in mind. A second approach, and the one used by researchers at George Mason University, is to prevent automation errors at the source by developing new interfaces that reduce the requirement for training. This approach requires close collaboration between researchers and manufacturers to collect data on current and prototype systems and begin to predict how system modifications will affect initial learning and training requirements. The strength of this approach lies in the tight coupling of real, applied problems with scientific theories, principles and methods. Coupling airline data with cognitive modeling and other analysis techniques allows us to develop better evaluation and training programs. By collaborating with manufacturers, we also ensure that our training research remains relevant as automated systems evolve.

During FY08, information about design, use, and training of automated systems was obtained through interviews and observations at several airplane manufacturers, training companies, and airlines. The research team completed a review of a report on a survey of pilot training, completed an automation research summary document, and initiated dialogue to develop conceptually-based training for visual approaches. Researchers also worked with the University of Central Florida on development of materials for their exemplar-based training for visual approaches, and completed production of a CD containing conceptual training developed for automated systems and background reports on automation training. This CD was circulated to 600 participants of the FAA-sponsored conference on automation.

Also during FY08, researchers continued to work with NASA on examining the transition to electronic documents on the flight deck that allows for improvements in technology as well as crew performance and overall flight safety. Recent NASA/FAA research identified Electronic Flight Bag (EFB) procedures, training and best practices that can measurably improve crew performance. Researchers also refined two documents into more usable checklists for operators to evaluate new EFBs.

Cockpit Task Demands

Summary: NASA researchers published a book titled *Multitasking in Real World Operations: Myths and Realities.* This book is the final report of a multi-year ethnographic study of cockpit tasks and crew performance in normal flight operations, conducted in collaboration with two major U.S. air carriers. The team found that the dynamic and concurrent nature of task demands in today's airliner was a major source of inadvertent failures to perform intended actions. Situations in which pilots are vulnerable to forgetting to perform intended actions are identified, and plausible reasons why even the most expert of pilots are vulnerable to error are discussed. The book concludes with

detailed guidance on countermeasures individuals and organizations can take to reduce vulnerability to error in these common situations.

Description: In conducting research on airliner cockpit demands, NASA researchers observed pilot training classes, and also participated as pilots in airline training for new hires. They analyzed flight operations manuals, observed actual flight operations from the jump seat, and discussed those observations with the crews. The results were used to generate search terms to identify an extensive set of reports involving concurrent task demands. The research team published a book titled *Multitasking in Real World Operations: Myths and Realities.* This book is the final report of their multi-year ethnographic study of cockpit tasks and crew performance in normal flight operations, conducted in collaboration with two major U.S. air carriers.

The team found that flight operations manuals, and the training associated with them portrayed cockpit tasks as if they were linear (each task performed in sequence), predictable in timing and nature, and under the moment-to-moment control of the crew. However, jump seat observations revealed cockpit work to be much more dynamic, with frequent interruptions, unexpected new task demands, and situations requiring tasks to be performed out of the expected sequence. Pilots often had to perform more than one task concurrently. The dynamic and concurrent nature of task demands was a major source of inadvertent failures to perform intended actions.

Prototypical situations were identified in which pilots are vulnerable to forgetting to perform intended actions: (1) Ongoing tasks are interrupted; (2) Tasks must be performed out of the normal, practiced sequence; (3) Tasks must be deferred; and, (4) Multiple tasks must be interleaved concurrently. Researchers were able to identify the cognitive demands of these prototypical situations and plausible reasons even the most expert of pilots are vulnerable to commit errors. The book provides detailed guidance on countermeasures individuals and organizations can take to reduce vulnerability to error in these common situations. Also, this study provides a basis for conducting more realistic cockpit task analyses for Advanced Qualification Programs. Although the book's examples are based on pilot performance, the principles and recommendations are treated in a way that they can be applied to an area of skilled operator performance.

Monitoring and the Use of Checklists

Summary: Analysis by NASA researchers revealed that errors in both monitoring and checklist execution are diverse in nature and frequent. A preliminary assessment of the cognitive factors underlying vulnerability to these errors will provide a foundation for developing countermeasures to reduce vulnerability. These countermeasures include training, design of checklists and operating procedures, and organizational policies.

Description: A NASA research team has completed 60 jump seat observations of how air carrier crews conduct monitoring and execute checklists in normal operations. These observations were conducted in six aircraft types at three airlines (two in the U.S. and one

in Canada), one of which in a major international airline and the other two of which are regionals. Preliminary analysis reveals that errors in both monitoring and checklist execution are diverse in nature and frequent. Only about 16% of these errors are caught. The team has completed a preliminary assessment of the cognitive factors underlying vulnerability to these errors, and this will provide a foundation for developing countermeasures to reduce vulnerability. These countermeasures include training, design of checklists and operating procedures, and organizational policies.

Flight Simulator Fidelity Requirements Research

Summary: FAA-funded human factors researchers at the Volpe Center are working to improve airline pilot training world-wide. Their goal is to ensure that training tools are available to face the challenges brought on by the shrinking pilot applicant pool, the decreasing prior experience of applicants, and the increasing complexity of the traffic mix and the pilot task with the transition to NextGen capabilities. Target areas are: (a) ensuring that flight simulator cueing requirements are sufficient to ensure positive transfer of pilot performance and behavior between the simulator and airplane, and (b) ensuring that cueing requirements do indeed contribute to this transfer.

Description: Much of initial and recurrent airline pilot training is accomplished using simulators. A great deal of interest centers on simulator fidelity requirements for effective training. Human factors research focuses on four tasks: (1) examining the effect of existing flight simulator requirements on the transfer of skills of pilots between airplane and simulator according to existing knowledge; (2) providing original research in cases where existing knowledge is inconclusive; (3) developing requirements, knowledge, guidance, and standards for the design, certification, and use of flight simulators based on all research findings; and (4) applying and disseminating research results in national and international forums. The overall goal is to improve air-transport-pilot training world-wide to ensure that training tools are available to face the challenges brought on by the shrinking pilot applicant pool, the decreasing prior experience of applicants, and the increasing complexity of the traffic mix and the pilot task with the transition to NextGen capabilities. Two important considerations are: (a) ensuring that flight simulator cueing requirements are sufficient to ensure positive transfer of pilot performance and behavior between the simulator and airplane, and (b) ensuring that cueing requirements do indeed contribute to this transfer.

A systematic examination of the requirements for Full Fight Simulators (FFS) and a subsequent empirical research program found no operationally relevant benefit from simulator platform motion. Researchers also found evidence that other aspects of simulation, such as the lack of realistic radio-communications, should be considered when trying to improve training. Recent activities include reviewing relevant literature and examining regulatory and research output, monitoring the impact of work accomplished in this program on industry and on other research and regulatory activities, and continuing to maintain and update a flight simulator fidelity requirements literature database at Volpe. This research is being coordinated with ICAO working groups.

Research is also focused on evaluation of the Full Flight Trainer (FFT), a fixed-base trainer with FFS-quality data. Planning, research design, setting up of data collection and analysis are underway. Researchers have also started looking at research needs for advanced maneuvers training (such as upset recovery) and have helped coordinate the work of the many entities exploring this issue. The goal is to examine the effectiveness of existing simulators for training and evaluation of advanced maneuvers.

Understanding Human Performance in Aviation - Barriers to Effective Performance

Summary: FAA-funded human factors researchers at the American Institutes for Research worked to address barriers to effective airline pilot and dispatcher performance brought on by temporary changes to the Notices to Airman or NOTAM system and data regarding the condition of aircraft operating surfaces at airports (field condition or FICON reports). This work produced reports on "NOTAM System Modernization: The Pilots' Perspective. Report Summarizing Input from the Pilot Input to NOTAM System Modernization Working Group", and "Field Conditions Data: The Airline Dispatchers' Perspective. Report Summarizing Input from the Dispatch Aviation Safety Action Program (ASAP) Field Conditions (FICON) Working Group."

Description: American Institutes for Research disseminated reports on Notices to Airmen (NOTAM) and Field Condition (FICON), along with a previous report from dispatchers regarding NOTAM data, to the FAA's Aeronautical Information Management Group (AIM) group, which is responsible for modernizing the NOTAM system. AIR also provided this information to AIM and other stakeholders via participation in a series of four *Digital NOTAM Working Group* meetings held between October 2007 and August 2008, and one FAA NOTAM Industry Day meeting. In addition to providing input to AIM regarding challenges associated with the use of NOTAM and FICON data and recommendations for change, AIR also provided AIM with human factors related guidance regarding the digital NOTAM data entry system. Finally, AIR disseminated FICON information to the Take-Off and Landing Performance Assessment Aviation Rule-Making Committee in the form of dispatchers' recommendations for change to Advisory Circular 150/5200-30B entitled, "Airport Winter Safety and Operations."

Effect of Electronic Flight Bag (EFB) Technology on Crew Performance

Summary: NASA is conducting research that supports development and implementation of EFB technologies. In collaboration with one airline's actual EFB implementation, researchers seek to understand and clarify the procedures, practices and training that lead to effective and improved crew EFB performance. This research is being accomplished by analyzing video recordings of crews flying with EFBs in line operational simulation, and instructor/evaluator assessments of EFB usage as they viewed the videos. The team

will develop and refine EFB implementation guidance for Part 121 operators in accordance with regulatory guidance. A draft of key results was prepared for the final report, *Electronic Flight Bag Procedures and Best Practices.*

Description: NASA research on the effect of Electronic Flight Bag technology on crew performance has several main elements. NASA takes the perspective of the end-users of the technology, the flight crews and operators who are developing and acquiring EFB systems to augment their fleet capabilities. For them, the technological advantage must be integrated into operations without degrading operational performance or safety. EFB systems create many changes for flight crews who must be able to operate in all conditions in accordance with company policies, procedures, training and practices. NASA also takes into consideration the operators' requirement to comply with regulations, standards and industry best practices. Research is facilitating clarification and communication of the authorization process.

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Research is also underway to help optimize implementation and use of new EFB software applications. These advanced applications are in the process of being implemented on the flight deck as we move into Next Gen technologies. They include airport moving maps, satellite weather, and new data overlays for electronic charts. Research will focus on cockpit procedures, crew best practices and training.

Structural Knowledge Analysis of Aviation Safety Reports - Pilot Skill Decay

Summary (Runway Incursions): The FAA established a new voluntary program in 2004 called the Runway Incursion Information and Evaluation Program (RIIEP) that is designed to gather information from pilots and maintenance technicians who have been involved in a runway incursion or surface incident. Researchers at the University of New Mexico are conducting a comprehensive statistical analysis to determine whether these data provide a better understanding of the factors underlying the occurrence of runway incursions and whether this information can then be used to guide implementation of various risk-reduction programs.

Summary (Pilot Skill Decay): The FAA historically has required airlines to perform recurrent training on pilots at standardized intervals of six months for captains and 12 months for first officers (Air Transportation Operations Inspector's Handbook, 2006). These intervals were motivated by required medical exams at six-month intervals rather

than established rates of forgetting for pilots' knowledge and skill. Under the Advanced Qualification Program (AQP), airlines can now propose alternative recurrent training intervals for pilots (FAA Advisory Circular 120-54A, 2006). However, the new training intervals must be justified by empirical pilot performance data. Researchers at the University of New Mexico are determining if there is a significant decay in the performance of critical maneuvers in the simulator and the degree to which this decay is influenced by training intervals

Description: In this project, researchers at the University of New Mexico are analyzing existing aircraft maneuvers validation (MV) and first look (FL) data collected from several carriers and fleets by the FAA over the past several years. In the prototypical evaluation/training session, pilot FL performance is evaluated by assessing their performance on a set of maneuvers without any pre-training. This is followed by the MV evaluation where pilots are trained to perform proficiently on a specified set of maneuvers. The primary finding coming out of these analyses will tell us whether we are seeing a significant decay in the performance of critical maneuvers in the simulator and the degree to which this decay is influenced by training intervals. In addition, contingent upon the nature of the data contained within the existing database, researchers are also assessing whether: (1) the decay is influenced by on-line practice of the maneuver during the retention interval; (2) if the level of initial training during MV improves retention on the subsequent FL assessment; (3) if retention is better for pilots flying short-aircraft which involve more on-line landing and take-off training. Preliminary analyses of these data show a small, but significant, loss in performance from MV training to FL assessment.

Using Mental Model Assessments for Training Design and Assessment

Summary: The structure of a pilot's knowledge may predict his/her performance while conducting operations. Valid knowledge structure evaluation tools and procedures have been developed yet many airlines rely on other assessment methods that may only evaluate superficial levels of a pilot's knowledge. This study at the University of Central Florida focuses on developing guidelines that will standardize the use of knowledge structure evaluation methods.

Description: Research has established that the structure of a pilot's knowledge may predict his/her performance while conducting operations. While valid knowledge structure evaluation tools and procedures have been developed (i.e., concept mapping and card sorting), many airlines rely on other assessment methods that may only evaluate superficial levels of a pilot's knowledge. Inadequate knowledge evaluation practices in aviation environments may be evidenced by the consistent findings of gaps and misunderstandings in pilots' knowledge of the automation they interact with. In an effort to encourage the use of knowledge structure assessment methods that can assess and diagnose misunderstandings or gaps, this study at the University of Central Florida focuses on developing guidelines that will standardize the use of knowledge structure

evaluation methods. Specifically, human factors researchers are focused on developing guidelines for using knowledge structure assessment methods that facilitate both valid and reliable evaluations of the knowledge structures pilots use to interact with an aircraft.

This project addresses the need for knowledge structure assessment guidelines by investigating factors that may influence the validity and reliability of concept map assessments by investigating the role check pilots play in the assessment process. Factors such as experiences with the assessment process and the information being assessed will be empirically investigated to determine the conditions under which these factors are optimal for producing the most valid (i.e., accurate) and reliable (i.e., inter-rater agreement) evaluations. Although this study focuses on knowledge structure evaluation, the guidelines produced here can be extended to other subjective assessment methods such as simulator observations.

Research on the Human Factors of Conveying Safety-Critical Information

Summary: One of the major sources of accident prevention in aviation comes from information gleaned from pilot reports of incidents that occur in flight. The Aviation Safety Action Program (ASAP) was developed to provide a means for collecting this information in a voluntary, secure environment. Researchers at the University of Central Florida are actively involved with research on systems that convey safety critical information. The research team is investigating safety critical information systems in an effort to optimize efficiency and usability of these types of systems.

Description: A major factor in aviation accident prevention is information gleaned from pilot reports of incidents that occur in flight. The aviation safety action program (ASAP) was developed to provide a means for collecting this information in a voluntary, secure environment. Ultimately, information collected from ASAP can provide valuable insight into aspects of flight safety that can lead to improvements in training, awareness, and policy. Among the challenges associated with this program is ensuring the array of information that can be addressed through ASAP is communicated efficiently and accurately. In support of the FAA's Voluntary Safety Program Office's programs, researchers at the University of Central Florida (UCF) are actively involved with research of systems that convey safety critical information including Notices to Airmen (NOTAM) and the ASAP Web Based Application Tool (WBAT) systems. UCF researchers aim to investigate safety critical information systems in an effort to optimize efficiency and usability of these types of systems.

This research addresses the need to investigate current information transmission systems within the aviation community to improve the flow of safety critical information. Through conducting empirical examinations on the quality, frequency, and type of information transmitted through these systems, we will better be able to address needs for these systems. By using human factors and psychometric principles, we intend to make recommendations on current and future information sharing programs

Assessment of Flight Attendant Fatigue

Summary: In 2005, Congress directed the Civil Aerospace Medical Institute (CAMI) to conduct a preliminary investigation of flight attendant schedules and potential vulnerability to fatigue. CAMI collaboration with NASA Ames Research Center produced a 2006 report that provided evidence that fatigue-related performance decrements were likely under the current regulations, and suggested six areas of research that would facilitate a more complete understanding of flight attendant fatigue and government-industry decision making. Citing the 2006 report recommendations, Congress recently directed CAMI to conduct analyses in the six areas: a survey of field operations; field research on the effects of fatigue; a validation of models for assessing flight attendant fatigue; a focused study of incident reports; a review of international policies and practices; and the potential benefits of training. Reports of these efforts are to be submitted to Congress not later than December 31, 2009.

Description: Congress directed the Civil Aerospace Medical Institute (CAMI) to conduct a preliminary investigation of flight attendant schedules and potential vulnerability to fatigue. In 2008, CAMI was directed to conduct analyses in six areas: a survey of field operations; field research on the effects of fatigue; a validation of models for assessing flight attendant fatigue; a focused study of incident reports; a review of international policies and practices; and the potential benefits of training. A CAMI Research and Technical Team was formed to coordinate and accomplish the six recommendations. The flight attendant fatigue survey was developed from existing fatigue literature and feedback from subject matter experts. The survey was designed to examine six key factors that contribute to flight attendant fatigue: (1) personal demographics (e.g., age, non-work responsibilities); (2) job demographics (e.g., workload, length of duty); (3) sleep loss; (4) circadian rhythm disruption; (5) nutrition; and (6) stress and emotional pressure. Generalizable results are critical to stakeholder acceptance of findings. Accordingly, CAMI researchers proposed a randomly-selected and representative sample from the approximately 100,000 flight attendants currently working for the nation's air carriers. Using this sampling approach, 31,000 flight attendants will be administered a survey. CAMI anticipates that of those receiving the survey, approximately 9,300 are expected to be returned (assuming 30% response rate). CAMI researchers are attempting to improve the response rate (and reduce error) by providing both an online and hardcopy version of the survey.

Coordination of the survey and field studies is underway with Air Transport Association's (ATA) Cabin Operations Committee, the Regional Airline Association's (RAA) Inflight Committee, the Coalition of Flight Attendants, and non-unionized airlines for focused assistance in accomplishing these recommendations. Additionally, pre-sampling tests of flight attendants and subject matter experts (SMEs) are being conducted to evaluate the relevance and quality of both the survey and the field study procedures, instructional quality, and to address unforeseen issues.

The field study will solicit recruitment of 210 volunteer flight attendants who will be compensated (paid as SMEs) for participation under a cooperative research agreement.

The field study is expected to begin in early November, 2008 and proceed over a five-month period with a draft report to follow at the end of April, 2009.

CAMI personnel have reviewed accident and incident reports involving flight attendants and will assess the potential role of fatigue in reported events. Researchers are reviewing NTSB and Aviation Safety Reporting System (ASRS) databases, and have identified a number of events for evaluation. Data from NASA's ASRS on-line data has been downloaded. There were 2,628 reports from flight attendants from 1990-2007. Additional data was received from NASA regarding aircraft information codes (type of aircraft). Categories have been identified for content analyses. Preliminary analyses of the data have begun.

CAMI personnel have compared US duty and rest regulations to those promulgated by other nations. The CAMI team has collected regulations/rules governing cabin crew rest, duty time limitations, and/or fatigue policies from 12 countries under Civil Aviation Authority and 31 countries governed by European Economic Community Regulations/JAA.

CAMI personnel have also collected information on a number of training programs. Recommendations will be provided for future flight attendant training based upon training given or made available previously. Updated guidance from new research accomplished under this Congressional Directive will be prepared.

The task will continue in FY09 with data collection, analysis, and reporting of all six projects. The approach will be to develop Technical Reports describing the results of each separate project before combining relevant aspects into a final report that will be submitted for distribution to Congress by December 31, 2009.

Fatigue Assessment under Ultra Long Range (ULR) Flight Operations

Summary: In December 2007 and January 2008, data were collected on 10 ULR New York to India flights from 23 pilots and 20 flight attendants. Measures included actigraphy, Psychomotor Vigilance Task (PVT) performance, and subjective logbook entries of sleep ratings, visual analogue mood scale (VAS) ratings, Stanford Sleepiness Scale (SSS) ratings, and ratings of the Sustained Operations Assessment Profile (SOAP). A briefing on all results to AFS-200 and Delta Air Lines is scheduled for early October 2008.

Description: In December 2007 and January of 2008, data were collected on 10 New York (JFK) to Bombay, India (BOM) ULR flights from 23 pilots and 20 flight attendants. Measures included actigraphy, Psychomotor Vigilance Task (PVT) performance, and subjective logbook entries of sleep ratings, visual analogue mood scale (VAS) ratings, Stanford Sleepiness Scale (SSS) ratings, and ratings of the Sustained Operations Assessment Profile (SOAP).

Four post hoc groupings of participants were formed with flight and cabin crewmembers that were scheduled for "better" vs. "poorer" sleep-time opportunities on the outbound and return segments of the trip, and whether those sleep-time opportunities were reversed during the two segments or remained the same. Differences in crew operations necessitated separate comparisons; pilots were scheduled for two sleep-time opportunities enroute, whereas flight attendants were scheduled for only one somewhat longer sleep-time opportunity; pilots were scheduled for 48 hour layovers vs. 24 hours for the flight attendants.

All data reduction and formatting has been completed. Analyses of the PVT, SOAP, VAS, and Sleep Ratings data have been completed. Specific trip parameters including block times, flight/duty times, and latitude/longitude waypoints, as well as actigraphy and logbook entries of sleep were entered into the Fatigue Avoidance Scheduling Tool (FAST™). A briefing to AFS-200 and Delta Air Lines on all results is scheduled for early October 2008.

Pilot Training and Experience with Transport Category Rudder Control Systems

Summary: The Rudder Survey Team completed a survey designed to understand the factors associated with: inadvertent, erroneous and unsafe rudder usage; determining the influence of rudder design on pilot input/response; and recommending what types of design requirements and training procedures may prevent accidents. Results were analyzed to identify the primary airplane flown and the country of primary employment as well as the items listed above. A technical report is scheduled for completion by the end of 2008.

Description: Several recent events indicate that rudder control systems may have been involved in a number of hazardous situations. System design, human factors, and pilot training are considered potential event factors. Therefore, CAMI and the William J. Hughes Technical Center collected data on pilot training and experience with transport category rudder control systems. The goal is to assess current airplane control characteristics, pilot interfaces, and training so as to better understand their relationship to pilot use/misuse of the rudder.

A survey designed to assess pilot training and experience with flight control and rudder systems provided vital information. The survey furthered the FAA's knowledge of pilot training and experience with transport category rudder control systems. Responses provide information on upsets in broad terms and also on specific aspects of pedal/rudder control systems. Results were analyzed to identify the primary airplane flown and the country of primary employment as well as the items listed above. Most pilots had unusual attitude training with training in the pitch axis, in the roll axis, and in the yaw axis. Pilots reported that they found recurrent simulator training to be effective. When asked if more training in transport airplane rudder usage would be beneficial, over half responded yes, and when asked if recurrent training in rudder usage would be beneficial, over three-

quarters responded yes. This information supplements anecdotal information and allows further evaluation of the factors that affect rudder use. Information gained from this research may be used to develop the following products: improved Code of Federal Regulations Part 25 aircraft certification rules, policy, and guidance; training guidance; and, responses to NTSB safety recommendations. A technical report is scheduled for completion by the end of 2008.

Sponsors were provided a briefing in spring 2008. A presentation will be made at the Aerospace Medical Association Conference.

Develop Baseline Operational Communications Database to Describe Current Operational Voice Communications between Native and Foreign Airline Pilots and Controllers during Oceanic Operations

Summary: An operational shortfall exists in our understanding of current operational communications in the en route environment and international voice communications within the National Airspace System (NAS). ICAO has mandated an English Language Proficiency Requirement, and the FAA lacks baseline data to gauge its effect on NAS operations and safety. By updating our communication databases, we will be able to measure how the English Language Proficiency Requirements will affect ATC operations and safety. Also, as digital voice communications systems and their applications emerge, it is important to know which messages may present a problem for non-native English speaking pilots.

Description: Five en route facilities provided at least 10 hours of pilot-controller voice communications. The facility selected time samples that were representative of peak international (i.e., oceanic) air traffic operations and peak traffic periods with the most communications-intensive operations. Fifty-one hours of air-ground transmissions were analyzed. Each controller transmission was paired with its readback and scored for accuracy. In the first of three reports, controller messages were classified according to complexity, message length, and pilot readback accuracy. For the second and third reports, aircraft call signs were used to classify transmissions by aircraft registry (US, foreign) and language (English, other). English language proficiency was examined for pilots in the second report, with communications problems in the third report, and controllers and pilots were graded on their level of language proficiency using the ICAO Language Proficiency Rating Scales.

For the first report, 93.8% of the pilots' readbacks were correct. When an error did occur, pilots experienced more difficulty reading back approach control high-complexity messages than departure control high-complexity messages or low-complexity messages from either approach or departure control. As message length increased, so did the mean number of readback errors, but only during the approach segment when pilots experience the most challenging aspects of their flights and controller messages are complex and lengthy. For the second report, communications were analyzed from 832 aircraft (77% US, 23% Foreign) for 4816 pilot transmissions (80% English, 20% other). In this

analysis, 5.8% contained problems. When English was the primary language, or pilots flew US aircraft, there were fewer communication problems, less time was spent on frequency, and fewer messages were transmitted than when pilots flew foreign aircraft or the primary language was not English. English language proficiency was a factor for many of the communication problems among foreign aircraft.

Three technical reports completed the review process: 1) The outcome of ATC message length and complexity on en route pilot read back performance, 2) Pilot English language proficiency and the prevalence of communication problems at five US air route traffic control centers, and 3) United States Airline Transport Pilot International Flight Language Experiences Report 1: Background Information, General/Pre-Flight Preparation and General/Air Traffic Control (ATC) Procedures.

Structured Interviews: Native and Foreign Airline Pilots' International Language Experiences

Summary: There is a lack of baseline data regarding the flight experiences of airline transport pilots (ATP) who fly internationally. Not surprisingly, research is needed to identify and fill the gaps in communications data that will contribute to the understanding of some of the language issues, communication problems and procedural differences these pilots encounter when flying internationally. Also, as digital voice communications systems and their applications emerge, it is important to know which messages may present a problem for non-native English speaking pilots.

Description: A structured interview was developed and administered to small groups of ATP-rated pilots to identify language issues that can become barriers to efficient and effective Air Traffic Control (ATC) communication. The structured interview was divided into nine sections: (1) Background Information, (2) General/Pre-Flight Preparation, (3) Word Meaning and Pronunciation, (4) Language Experiences in Non-native English Speaking Airspace/Airports, (5) Language Experiences in Native English Speaking Airspace/Airports, (6) Non-native English Speaking ATC/Native English speaking Pilot Communication, (7) ATC/Pilot Same versus Different Language Interaction, (8) Communication Problems, and (9) Technological Interventions. Forty-eight airline transport pilots from American, Continental, Delta, and United airlines were interviewed, and twelve pilots from Aeroflot, Alitalia, China Air, and LAN Chile airlines were interviewed.

The pilots' responses had several major thrusts: Cultural differences exert an important, nearly undetectable influence on international aviation; English language proficiency is deficient and hampers effective communication; Party-line (single-frequency) communications in English facilitate situational awareness. When mixed languages are on frequency, party-line communications pose a safety concern and impede situational awareness. In addition, pronunciation and naming conventions for locations and other identifiers lack a uniform pronunciation; three- or five-letter identifiers may not be connected with the pronunciation. There is no uniform agreement as to what standard

phraseology is or should be. Technological advancements such as datalink may help solve some of the language problems. Sponsors were provided a briefing.

Advancing Aviation Safety: Threats, Errors, and their Management in Normal Operations

Summary: The University of Texas Line Operations Safety Audit (LOSA) uses non-jeopardy cockpit observations conducted during normal flight operations. In FY08, the research team delivered a snapshot of system performance strengths and weaknesses as measured by the Threat and Error Management (TEM) framework

Description: The final year of this grant represented the end of an era for The University of Texas Human Factors Research Project. After over 40 years of research, Dr Robert Helmreich retired in June 2007 and the project officially closed its doors at the conclusion of this grant in 2008. Drs. James Klinect and Ashleigh Merritt will continue to provide TEM and LOSA research through a private organization called The LOSA Collaborative. Until then, the final year of grant activities were spent on producing research that will advance TEM and LOSA concepts with particular focus on providing information to update the ICAO LOSA Handbook (Doc 9803) and FAA LOSA Advisory Circular (120.90).

In November 2007, the First LOSA User Group Meeting was organized by Dr. James Klinect. The meeting was hosted by Cathay Pacific Airways in Hong Kong and over 45 participants from 17 LOSA airlines were in attendance. The meeting consisted of several breakout group discussions around five central questions:

1. What are some of your airline's benefits and frustrations with LOSA data?
2. How did your airline structure its safety change process in response to LOSA results?
3. What are some of the organizational changes made as a result of LOSA? Did they work?
4. What is the curriculum of your airline's TEM training courses?
5. What are some your airline's recommended improvements to LOSA?

In March 2008, researchers transcribed over 40 hours of recordings from the breakout groups. These transcripts are being analyzed for a paper on LOSA best practices. Dr. Klinect conducted two LOSA workshops at the FAA Voluntary Safety Conference in San Diego. The workshop was well attended and the enthusiasm for TEM and LOSA continues to be strong in the commercial aviation industry.

Flight Technologies and Procedures

Flight Symbology

Summary: The objective of this project at the Volpe Center is to determine what symbology is appropriate for electronic flight displays by providing data and

recommendations. Past and current work focused on aeronautical charting symbology. Symbology for traffic displays is now being considered. Results of this research are intended to be of use to the FAA, RTCA, the International Civil Aviation Organization (ICAO), other civil aviation authorities, and manufacturers who develop and/or depict symbology.

Description: Researchers at the Volpe Center are working with the SAE International Aerospace Behavioral Engineering Technology Committee (SAE G-10) Aeronautical Charting Committee to update an industry recommendations document on charting symbology. The Volpe Center is also coordinating research on traffic symbology with the RTCA Special Committee (SC) 186, Automatic Dependent Surveillance–Broadcast (ADS-B) Cockpit Display of Traffic Information (CDTI) subgroup.

Data have been collected from approximately 140 pilots without instrument ratings in regard to their use of lines and linear patterns. Pilots first sorted several lines and linear patterns based on how much they use and recognize them. Then, the pilots tried to name a few specific linear patterns that were expected to be relatively well known, even though the patterns were shown in isolation. The new data were combined with data from more than 100 instrument-rated pilots collected in FY07. Results of the study found that pilots use and recognize lines and linear patterns differently based on their qualifications (instrument-rated vs. not), types of flight operations (e.g., air transport, corporate, or private), and typical flight length. Recognition of the linear patterns in isolation was a difficult task, although some patterns (e.g., for restricted airspace) were more recognizable than others (e.g., for an air routing traffic control center).

Near-term research needs related to traffic symbology were defined in coordination with the RTCA CDTI Symbology Subgroup. The first task was to complete a comprehensive review of literature in this area. The next task was to document and prioritize research issues for traffic symbols. The highest research priority was determined to be the intuitiveness of the symbols. Several experiment design options to address this issue were proposed and discussed. Over 130 articles were considered and documented as part of the literature review. Only four references described studies in which symbol issues were tested directly; approximately 30 papers have implications for symbol design, and the remaining papers are of low relevance to the current research focus but may have implications for future research. The articles are being posted on an FAA Sharepoint Website so that they are accessible to all RTCA CDTI group members

A draft technical report from FY07 on navigation-aid and airport symbols, lines, and linear patterns that are currently in use was updated with further information from manufacturers. Definitions for several line types were also obtained and included in a new appendix for the report. A final technical report documenting navigation-aid and airport symbols, lines, and linear patterns currently in use was completed and published. Nine electronic display manufacturers and four paper chart providers submitted material for the report.

Electronic Flight Bags

Summary: Human factors research is providing aircraft certification, operational approval, and training guidance to mitigate risks associated with implementation and integration of electronic flight bags (EFBs) on the flight deck. The goals of this work at the Volpe Center are to (1) identify, understand, and help the FAA address human factors issues related to EFBs, and (2) support the FAA in the development of EFB-related policies and guidance.

Description: Volpe Center researchers are updating and finalizing a draft report on EFB-related safety events in order to understand how EFBs are impacting the overall safety of flight operations. Thirty-eight relevant events were gathered for this report from the public online Aviation Safety Reporting System (ASRS) database. In addition, two accident reports from the National Transportation Safety Board (NTSB) that call out the EFB as a contributing factor were reviewed. Recommendations were provided to the FAA regarding EFB guidance that was prepared for inclusion in the Flight Standards Information Management System (FSIMS). The revised FAA guidance was based on past work done by the Volpe Center to develop Notice N8200.98 (October, 2007). The new guidance was prepared between January and July, and involved several rounds of comments and updates. The guidance is currently undergoing internal FAA coordination as of September 2008.

Results of the review of EFB-related safety events are described separately for the ASRS data and the NTSB reports. Descriptive statistics for the ASRS events show that the most common anomaly to occur was a spatial deviation in heading, altitude, or speed. Underlying EFB issues are also ascribed to each of the events. One key issue is related to display configuration of charts, which can induce workload and may also cause the pilot to miss important information. A second key issue is the introduction of the EFB technology; several pilots who were new to the EFB mentioned that they had difficulty using it effectively, and this difficulty was a contributing factor in the safety event.

Both NTSB reports identified the use of an EFB for calculation of landing distance as a contributing factor. The key issue in one report was that assumptions underlying the performance calculations on an EFB must be presented to the crew as clearly as they are shown on paper-based performance tables. In the other NTSB report, the key issue was assessment of the adequacy of training and procedures for using EFB performance calculations functions.

Human Factors Generic Guidance

Summary: The objective of this task at the Volpe Center is to identify and compile FAA human factors policies and guidance, and other related research on a variety of flight deck systems. FAA Aircraft Certification teams have often noted a number of reoccurring human factors/pilot interface issues in the review of new avionics displays. Human factors requirements and guidelines are provided in Technical Standard Orders (TSOs),

Advisory Circulars (ACs), and RTCA Minimum Operational Performance Standards (MOPS) for specific avionics systems, but many of the issues are related. A general guidance document is being developed to help FAA Aircraft Certification specialists identify and resolve common human factors issues in avionics submitted for approval.

Description: The Volpe Center worked with the FAA to define the scope of a general guidance document to help FAA Aircraft Certification specialists identify and resolve common human factors issues in avionics submitted for approval, and to identify important sources to reference. The document is intended to apply to all types of display systems (e.g., Electronic Flight Bags (EFBs), Global Positioning System (GPS) displays, and electronic map displays) used for all types of operations (Part 91, Part 121, Part 125, and Part 135). Two key references provided the framework. The first was AC 25-11A, *Electronic Flight Deck Displays*, issued on June 21, 2007. AC 25-11A provides general guidance for showing compliance for the approval of installed electronic display systems. The issues addressed in AC 25-11A served as a starting point for identifying topics for the generalized guidance document. The second key reference was expired FAA Notice (N) 8110.98, *Addressing Human Factors/Pilot Interface Issues of Complex, Integrated Avionics as Part of the Technical Standard Order (TSO) Process*, which was originally issued on May 5, 2002. This notice provided the basis for the organization and format of information for each topic. Other FAA policy and guidance (e.g., FAA Code of Federal Regulations (CFRs), TSOs, ACs, RTCA MOPS), industry documents (e.g., SAE documents), and general human factors texts were reviewed to identify appropriate considerations.

A first draft of the general guidance document was submitted to the FAA for review in September 2008. Topics address system hardware, display and organization of information elements and features, and design of control devices. A discussion of the importance of a design philosophy and considerations for assessing workload, managing errors, automation, and protecting against and managing system failures are also included. The considerations for each topic fall into one of two categories: *FAA Requirements and Guidance* and *Other Recommendations*. *FAA Requirements and Guidance* consist of human factors material excerpted from FAA CFRs, ACs, TSOs, and independent documents invoked or referenced by the FAA (e.g., RTCA and SAE publications). *Other Recommendations* provide additional guidance from design standards, human factors texts, research articles, and reports. More information about the topic is provided in two sections following the considerations: *Background* statements describe the rational for the guidelines and what the potential trade-offs in design might be; and *Examples* provide illustrations of the problem and describe design solutions that illustrate how a consideration could be or has been implemented and is in current practice.

Surface Moving Maps

Summary: Researchers at the Volpe Center are supporting development of appropriate guidelines and approval criteria for surface moving maps depicting ownship position,

regardless of whether they are installed or portable. It is generally accepted that the use of a surface map improves the flight crew's situation awareness and increases safety in taxiing on the airport surface. Manufacturers are considering several advanced functions that potentially present human factors certification issues for the FAA (e.g., indications or alerts of potential runway incursions, integration of air traffic control instructions for taxi). It is important to understand what additional guidance for establishing minimum standards and best practices is needed to support implementation and integration of surface moving map displays on the flight deck.

Description: Three main activities were conducted at the Volpe Center in FY08 regarding implementation and integration of surface moving map displays on the flight deck. First, a list of research issues was identified based on a preliminary analysis examining the circumstances leading to runway incursions and a glimpse of the state of the industry with respect to surface moving map technology. Second, a formal industry review was started to identify what information is being depicted and what functions are being implemented. Of particular interest are the presentations of ownship, traffic, visual or auditory indications or alerts, and route guidance. Manufacturers and research organizations developing surface moving map applications have been identified based on participation in a previous industry review, presentations at industry meetings, and a web search. Third, the Volpe Center reviewed existing guidance for evaluation of the surface moving map application to understand any potential limitations in the use of this technology and to identify possible mitigations. Two topics were of interest. One was the accuracy specified for depiction of ownship position and the likelihood of depicting ownship on an incorrect runway or taxiway. The other was the presentation of runway incursion indications and alerts and their effectiveness depending on where they are presented in the pilot's field of view.

Two primary areas of research were identified. The first was a need for guidance to support the development of runway incursion indications and alerts. Since the surface moving map may be presented on installed or portable display systems, the location of any alerts or indications in the pilot's field of view may vary. A literature review is in progress to provide information on this issue and an experiment to address issues related to the design of effective runway incursion indications and alerts is being designed.

The second area of research was to understand the implications of the allowable tolerance for the depiction of ownship position. The Volpe Center documented the likelihood of depicting ownship on an incorrect runway or taxiway using information regarding the configuration of runways and taxiways at U.S. airports and the distances between them to determine the potential for error in ownship depiction. Characteristics of runway incursions and the results of research to understand why pilots get lost are also included.

Instrument Procedures

Summary: The goal of this Volpe Center effort is to develop human factors guidelines for the design of instrument procedures and associated charting in order to ensure that these procedures are usable, easily flyable, and not prone to pilot errors because of design

characteristics that do not adequately account for human performance and limitations. This research will support work being done by FAA AFS-400 and AVN. Results will support improvements in instrument procedure design criteria, including incorporation of new concepts such as Required Navigation Performance (RNP) for Area Navigation (RNAV) procedures.

Description: The goal of the first stage of this instrument procedures design project is for the Volpe Center to become familiar with the research issues and various implementation perspectives related to RNP/RNAV. In addition, researchers are working towards generating a plan for research activity in this area in collaboration with the project sponsors. In order to accomplish these goals, the research team attended and participated in forums such as the Communications, Navigation, and Surveillance (CNS) Task Force, Pilot-Controller Procedures and Systems Integration (PCPSI) working group, and the Aeronautical Charting Forum (ACF). Briefings at the CNS Task Force meetings provide a range of information regarding policy and technical issues affecting the RNP/RNAV community. The current task of the PCPSI group is to document RNP/RNAV lessons-learned by gathering input from experts from industry and government who have been involved in implementing RNP/RNAV procedures. The ACF Instrument Procedures group consists of charting and aviation experts who come together to document and address highly technical and operational issues related to instrument procedures. In addition to participating in these formal group discussions, Volpe Center has initiated informal discussions with researchers, charting experts, and airline staff about these issues.

Through discussions with AFS-470, Volpe Center has concluded that research in this area should begin with a careful look at the design and charting of departure procedures. These charts are typically highly complex and non-standardized, making them especially difficult to use accurately. This research area ties in well with activities in the ACF, so the Volpe Center has proposed that the ACF create a working subgroup to address this issue. The goal of the subgroup will be to flesh out ideas and plans for research to improve the design and usability of departure charts.

Color Vision Requirements for Pilots

Summary: Completed a color vision/hypoxia study that examined the effects of mild hypoxia on normal and color-deficient pilots' color discrimination. A presentation at an annual meeting of the Aerospace Medical Association summarizing a portion of the data has been submitted for review. Measured the colors used in modern glass cockpit displays including a Boeing 777, an MD-80, and several military aircraft. The chromaticities of airport lighting systems including the Precision Approach Path Indicator, Visual Approach Slope Indicator, taxiway, and runway lights have been measured at 20 airports. This research will determine whether current color vision screening tests are adequate, given the increased color usage inside the cockpit.

Description: Although the FAA has maintained a color vision standard for pilots for many years, manufacturers have continually modified the pilot's tasks by introducing new technology that uses color to alert, inform, direct, and capture attention. During FY08, the major objective was to document colors used in modern glass cockpits, and in the airport environment, and colors to determine whether the current color vision screening tests are adequate, given the increased color usage inside the cockpit.

Color chromaticities were made using a Minolta CS-100 colorimeter. The size of the text and type of symbology of color-coded information were recorded along with placement, documentation of other colors on the display, target/background combinations, usage, and criticality of the information. The colors in use in the cockpit and in the airport environment will be used to create a generic work-task to compare performance against currently approved color vision screening tests and with new computer-based screening and diagnostic tests. The measurements obtained from airport lighting will serve two purposes: to measure the variability resulting from longtime exposure to heat, cold, ice, sun, and exposure to the incandescent lamps that burn 24 hours per day, seven days per week; and to document the in-service chromaticities and the range of those chromaticities resulting from use.

Data collection forms, database formatting, and chromaticity display graphs have been completed and 90% of the data that has been collected has been screened and entered into the database. During 2008, the color vision/hypoxia study was completed. Colors used in modern glass cockpit displays including a Boeing 777, an MD-80, and several military aircraft were measured. The chromaticities of airport lighting systems including the Precision Approach Path Indicator, the Visual Approach Slope Indicator, taxiway, and runway lights have been measured at 20 airports. Additional trips will continue to include cockpit simulators, airports representing various environmental/climatic zones, additional aircraft manufacturers, and general aviation aircraft.

Weather in the Cockpit Baselining and Assessment

Summary: Documented current and projected weather information needs and assessed gaps in current and projected weather-information products. Phase 1 report was submitted. An assessment of weather information use in Airline Operations Centers was initiated. This research establishes criteria for the organization and presentation of weather information to allow pilots to more safely and efficiently reach their intended destination without encountering significant weather hazards.

Description: Adverse weather is both a challenge for safe flight operations and a significant limiting factor for airspace capacity. In air transport operations, numerous takeoff and landing accidents have followed encounters with convective weather and winter precipitation. Predicting and avoiding weather and determining when conditions have deteriorated sufficiently to increase risk requires a great deal of attention from air transport pilots and airline operation centers. The Joint Planning and Development Office (JPDO) has articulated a vision for the Next Generation Air Transportation System

(NextGen) that expects a greater degree of collaboration between pilots and controllers in weather-related decision making and presumes a degree of shared situation awareness beyond current systems. Pilots and controllers will need consistent understanding of the weather situation to collaboratively resolve challenging flight conditions. As cockpit and air traffic weather systems and products enter the airspace system, they should facilitate both near-term and future operations.

To support this transition, CAMI: assembled information on near-term and envisioned weather information requirements for the air transport and general aviation cockpit, and for airline operations center personnel who support air transport operations assessments on weather products now available or entering the marketplace; documented the maturity and use of these products; and identified gaps between product capabilities and information needs. In addition, CAMI personnel are identifying key requirements for integration or connection between cockpit and air traffic needs and products.

Data were extracted from a number of sources (1993 National Aviation Weather Users' Forum, previous surveys/interviews of pilots, extant literature) and combined to define the categories and specific types of weather information pilots require and how they prioritize them by phase of flight. Data preferences and prioritizations were found to be consistent across pilots performing different types of activities and consistent, with minor variations, across levels of pilot experience. A Phase One report was completed. An assessment of weather information use in Airline Operations Centers will continue into next year.

An Updating of Allowable Manual Control Forces in Aircraft Control Systems

Summary: The objective of this effort was to update FAA Regulations 25.143(c) and 23.142(c) with current information based on present and future demographics and current and anticipated control-input devices to be found in Code of Federal Regulations (CFR) Part 25 and Part 23 aircraft. Specialized equipment was designed and fabricated for the offsite data collections, with modifications and enhancements being made to collect joystick data for the second sample of Part 121 pilots and nonpilots (flight attendants). Data from the last sample of Part 121 pilots (both women and men) suggested that not all of the female pilots flying Part 121 operations today are likely to be able to meet or exceed the allowable values in the CFR. A proceedings paper presenting the second part of the findings was accepted for the 2008 Annual Meeting of the Human Factors and Ergonomics Society.

Description: The objective of this effort was to update FAA Regulations 25.143(c) and 23.142(c) with current information based on present and future demographics and current and anticipated control-input devices to be found in part Code of Federal Regulations(CFR) part 25 and part 23 aircraft. While the intent was to provide data relating to the maximum forces, both momentary and sustained, that could be exerted by the pilot, it was also intended that information/recommendations be generated concerning

minimum forces. Additionally, a recommendation was sought regarding what percentage of the population should be accommodated in the setting of maximum-force requirements.

A survey of the literature was conducted to determine to what extent guidelines and standards existed for the application of force to assorted aviation control devices. A number of sources were consulted that used reasonably large samples of either military personnel or the civilian population. Additionally, empirical data collections were conducted at CAMI and at three remote sites to collect force-application data for both pilots and nonpilots with the intent of comparing those results with the reference sources. Specialized equipment was designed and fabricated for the offsite data collections, with modifications and enhancements being made to collect joystick data for the second sample of Part 121 pilots and nonpilots (flight attendants).

Data from the last sample of CFR Part 121 pilots (both women and men) suggested that not all of the female pilots flying Part 121 operations today are likely to be able to meet or exceed the allowable values in the CFR. It should be noted that the lower-percentile values appeared to be in agreement with previously obtained data distributions. As such, the older data appear to be usable for our purposes. Some of these values, however, may not have a significant impact in some systems, particularly in fly-by-wire side-stick aircraft where proportional force feedback may not be felt as readily. The values presented in HumanScale 4 (Diffrient et al.) appear to suffice for the women's performance in that they are consistent with the present findings. The data obtained during this project should provide a foundation from which data can be developed to guide future policy decisions to be based upon those norms if the distributions are deemed equivalent.

Synthetic Vision for Primary and Multifunction Flight Displays

Summary: The objective of this project was to determine the potential effects on pilot performance resulting from incorporating synthetic vision system features into primary-flight and/or multi-function displays. The intent was to generate data that could be used to formulate appropriate certification criteria across a number of platforms on which this graphical imagery may be hosted (both aircraft-referenced and pilot-referenced display systems). In addition, researchers sought to obtain data that could be helpful in assessing levels of operational credit that might be granted for the use of such systems. Findings were used to assist in the preparation of the Minimum Aviation System Performance Specifications (MASPS) for Synthetic Vision Systems.

Description: This project determined the potential effects on pilot performance resulting from incorporating synthetic vision system features into primary-flight and/or multi-function displays. A survey of the literature was conducted to determine to what extent guidelines and standards for the design and use of pictorial imaging displays (synthetic vision, enhanced vision, perspective primary flight displays) had been developed, and what data regarding both display design and human performance were available that had not already been captured in a guideline or a standard. A number of references,

documents, and guidelines were found that had direct or indirect bearing on the issues involved in synthetic vision systems, enhanced vision systems, and perspective primary flight displays. These references were enumerated, and in some cases summarized, and forwarded to the sponsor. Findings were also used to assist in the preparation of the Minimum Aviation System Performance Specifications (MASPS) for Synthetic Vision Systems. Participation on RTCA SC-213 continued throughout the year. MASPS for synthetic vision systems were nearing completion by SC-213. Participation on the FedEx concept demonstration with AFS continued.

Vertical Flight

Terrain Awareness and Warning System (TAWS) Feasibility for Helicopter Operations

Summary: CAMI personnel assisted with the Minimum Operations Performance Standard for helicopter terrain awareness and warning systems completed by RTCA SC-212. Simulator data collection by the University of North Dakota was supported by CAMI personnel in the Vertical-flight General Aviation Research Simulator. Data regarding pilot response to terrain alerts/warnings were collected by CAMI personnel and the results were provided to SC-212 during the preparation of their document.

Description: Due to advances in TAWS technology and the rotorcraft controlled flight into terrain (CFIT) accident frequency, the NTSB has recommended that alerting pilots in rotorcraft operations of their proximity with terrain would be beneficial (NTSB Safety Recommendations A-06-19 through -23). Specifically, the NTSB has recommended that all emergency medical system (EMS) aircraft be equipped with TAWS; that the TAWS regulation be extended to turbine-powered rotorcraft certificated for six or more passenger seats; and that operators provide training to ensure the crew can use the system.

A survey of the literature was conducted to identify relevant guidelines and human performance data for support of research being performed by the University of North Dakota (UND) and for document preparation of Minimum Aviation System Performance Specifications by RTCA SC-212. Additionally, scenarios and protocols were developed for data collection on pilot response to terrain alerts/warnings to be conducted during simulator trials run in conjunction with UND.

Minimum Operational Performance Standards for helicopter terrain awareness and warning systems (HTAWS) were completed by RTCA SC-212. Data regarding pilot response to terrain alerts/warnings were collected by CAMI personnel and the results were provided to SC-212 during preparation of their document.

Unmanned Aerospace Systems

Documentation of Sensory Deficiencies in the Operation of Unmanned Aircraft Systems (UAS)

Summary: CAMI personnel supported the UAS Program Office through database development and participation on industry committees developing guidance for integration of UAS into the NAS. Work completed to date includes an analysis of manned aircraft sensory information and other analyses. Researchers generated a technical report summarizing the findings of this research.

Description: Unmanned aircraft are those without an onboard pilot. UAS pilots do not have the same amount and types of sensory information available to them as pilots in manned aircraft. An assessment is needed on how these sensory deficiencies might affect the safety of UAS flights.

Work completed to-date includes: an analysis of manned aircraft sensory information; a comparison of manned sensory information to sensory information available to the unmanned aircraft pilot; a review of remediations for sensory deficiencies from the current UAS inventory; a review of human factors research related to enhancing sensory information available to the UAS pilot; and a review of current FAA regulations related to sensory information requirements.

A technical report has been generated which summarizes findings of the research. This report is scheduled for final publication by the end of 2008. The research proposed for FY09 consists of consolidating the analyses and recommendations from FY08 and incorporating those recommendations in the work of several standards working groups. These working groups include at least the following: RTCA Special Committee 203; SAE-G10 working group on unmanned aircraft system training guidelines; FAA – EUROCONTROL Memorandum of Cooperation (MoC), Annex 4, Action Plan 24 Working Group for Unmanned Aircraft Systems; and the UAS Program Office Working Group 2 on Control Station Design Issues.

Modify, Test, and Validate Vision Model to Predict Target Detection and Recognition

Summary: NASA researchers conducted controlled laboratory experiments to measure visibility of a range of aircraft for a set of human observers. The data were used to validate a new general model that can be used in a broad range of aviation human factors applications.

Description: The FAA seeks to characterize the ability of unmanned aerial system (UAS) viewing systems to support target detection and identification. Existing system evaluation methods require expensive and time-consuming subjective experiments. This project seeks to replace subjective testing with the Spatial Standard Observer (SSO), a simple

model of human detection and discrimination. The current goals of the project are: (1) to measure visibility of aircraft at various distances and under various viewing conditions using human observers, and (2) compare the predictions of the SSO model to the human visibility data. In the experiment, aircraft images were created using computer graphics from geometric aircraft models. The aircraft differed in type, distance, orientation, and brightness relative to the background sky. Human observers with normal visual acuity attempted to detect the aircraft images, and from their performance, a measure of the visibility of each aircraft was derived. The completed data set shows profound effects of aircraft coloration and size (distance).

The SSO is a simple model of visual pattern detection developed by NASA researchers to simplify visibility predictions in a broad range of technical applications. Researchers generated an SSO visibility prediction for each aircraft image, and compared these predictions to the human data. This analysis shows that the SSO provides an excellent prediction of contrast detection thresholds for aircraft that vary with respect to type, distance, orientation, and contrast. This validates the use of the SSO in predictions of aircraft visibility. To our knowledge, this is the first effective tool for prediction of aircraft visibility. This tool will simplify calculations of effectiveness of UAV viewing systems and help to address the UAS "see and avoid" problem.

Unmanned Aerial System (UAS) Ground Observer Requirement

Summary**:** This research provides empirical data on which to base UAS ground observer requirements and to test proposed models of detection and visibility. Accomplishments to date include: (1) Completion and approval of a test plan to carry out data collection; (2) Submission and approval of a human subjects research protocol allowing researchers to proceed with experiments; (3) Data collection; (4) Data analysis.

Description: The use of unmanned aerial systems (UAS) has been proposed for many civil and military applications within the National Airspace System (NAS). In order for UAS to be operated within the NAS, flights must comply with CFR 91.113 which outlines the "see and avoid" responsibilities for aircraft operators. One solution for meeting these requirements proposed by UAS operators is employment of ground observers to monitor traffic, assess collision probability, and provide operators with timely collision avoidance information. However there is little data on how well UAS operators can perform the tasks asked of them. The goals of the present research are to: (1) determine the limits (size and distance) of observer visual detection and identification for UAS; (2) measure the accuracy of observer judgment of relative distance and altitude; (3) quantify the ability of observers to judge collision probability; and, (4) provide empirical data with which to test proposed models of detection and visibility.

A test plan was submitted and approved by the FAA. This plan includes several different experiments that: directly measure observer detection given uncertain UAS locations; detect UAVs from a known location; provide judgments of distance and altitude; and,

examine collision potential and a means of collecting image data at detection thresholds. A protocol for human subject research has been approved.

Preliminary data was collected at a test site in Oregon in order to work out details and logistics of data collection. Data collection is currently ongoing at the site. Over half of the data have been collected on all of the experiments. In addition, image data have been collected at detection threshold. These image data will be shared with researchers in the military and NASA who are developing models of detection and visibility. Further data collection is planned at the site as well as a site at New Mexico State University. These data will supplement those collected in Oregon and provide detection data that includes additional models of UAS as well as varied backgrounds on which to measure detection. A final report including recommendations for ground observer requirements is due in the fall of 2009. These data and the final report will aid in decision making and facilitate integration of UAS operations into the National Airspace System.

Air Traffic Control Tower & UAV See-And-Avoid Visibility Analysis Tool Advances

Summary: This research provides the FAA two user-friendly software tools that: (1) provide quantitative information on the impact of air traffic control tower (ATCT) height and placement on aircraft visibility (the FAA Vis tool), and, (2) provide quantitative information on the available time that a unmanned aircraft system (UAS) operator would have to respond to a potential conflict with other manned and unmanned aircraft (the See-And-Avoid tool). The primary objective for FY08 was to *calibrate* these two visibility analysis tools by experimentally determining the field-of-view (FOV) search-time equations, the target (aircraft) *discrimination* difficulty criteria (N_{50} for *detection, recognition, and identification*), and the proper *characteristic dimensions* for aircraft, through execution of two human perception (HP) experiments/tests. An additional FY08 objective was to begin to validate these tools through participation in the FAA-sponsored ground observer field test.

Description**:** The technical approach that the U.S. Army Research Laboratory (ARL) utilized to calibrate two visibility analysis tools was to team with the U.S. Army's Night Vision and Electronics Sensor Directorate (NVESD) to develop and execute two HP experiments. The first HP experiment was designed to measure human response time and *detection* accuracy to displayed images containing variably-*sized* aircraft images synthetically placed into real sky or terrain backgrounds at random locations in the FOV. The second HP experiment was designed to measure the ability of human observers to *recognize* and *identify* aircraft images synthetically placed into selected background images with a range of spatial *blurs* applied to the displayed images. For both experiments, the general approach was to collect high-contrast, high-resolution, visible-band digital images of several *scale-model* aircraft from several perspectives, and high-resolution, visible-band images of real (natural) sky and terrain backgrounds.

Both the FAA Vis and the UAS See-And-Avoid visibility analysis tools have been completed and tested. Both tools exist as Windows-executable applications and are now available for use on the Internet @ www.hf.faa.gov/visibility. Execution of the first *detection* HP experiment was completed in November 2007. Based on the results of the *detection* HP experiment, the square root of the area of a maximally-sized cross-sectional rectangle ("Rectangular Area" metric) is judged to be the best (proper) *characteristic* (critical) *dimension* metric for *aircraft*. (A report on

the results of the *detection* HP experiment is available on request.) An experiment design document for the second *recognition* and *identification* HP experiment has been developed; execution and completion of this experiment is expected during the first quarter of FY09.

Aviation Maintenance

Development of Guidelines for Effective Implementation of an Aviation Safety Action Program for Aircraft Maintenance Organizations

Summary: Aviation Safety Action Programs (ASAP) identify and help correct adverse safety events that are otherwise not likely to come to the attention of the FAA or company management. There are now 45 air carriers with maintenance ASAP programs. Issues addressed in FY08 include: evaluation of maintenance human factors training, facilitation of communication between maintenance organizations, and exploration of connections between maintenance resource management training and ASAP programs. A website was developed to enhance information sharing: http://parks.slu.edu/departments/avsc/MEASAP/ . In addition, an outline of a Maintenance ASAP Handbook was developed.

Description: The primary purpose of an Aviation Safety Action Program (ASAP) is to identify and correct adverse safety events that are otherwise not likely to come to the attention of the Federal Aviation Administration (FAA) or company management. Prior to the start of this study in 2003, there were twenty-eight air carriers with flight ASAP programs and only six organizations with maintenance ASAP programs. As of September 2008, there were 45 Maintenance ASAP programs—clearly, the awareness is continuing to increase and, to a certain degree, this research project is contributing to the dissemination of information regarding ASAP programs.

In FY08, three key issues were addressed by researchers at the University of St. Louis: (a) evaluation of maintenance resource management (MRM) or maintenance human factors training, (b) facilitation of continued communication between the various maintenance organizations—both with and without an ASAP program, and (c) exploration of connections between MRM training and ASAP programs. Additionally, the research team continued to support the Maintenance ASAP Information Sharing meetings and developed a website http://parks.slu.edu/departments/avsc/MEASAP/ .

Review of MRM training data (pre- and post-training surveys) was initiated at select industry partners. A total of 2,391 responses were collected. Their responses were measured across four previously established scales: communication and coordination, relational supervision, conflict avoidance, and recognition of stress effects. Results from this study indicate that MRM training not only continues to produce positive attitudinal changes, but "relational supervision" is critical to achieving benefits of this training. Analysis of the MRM data partially confirmed the validity of a conceptual model.

The Maintenance ASAP research program continued to serve as the connector and facilitator of communication between various maintenance organizations, including those

from the Air Traffic Organization (Technical Operations) to enable the transfer of best practices across organizational boundaries and to create a support group of practitioners. Based on the industry-wide interest in connecting maintenance human factors programs and ASAP programs, an outline of Maintenance ASAP Handbook was developed.

Air Traffic Control/Technical Operations

Program Description

The Air Traffic Control/Technical Operations (ATC/TO) Human Factors Program is managed by Dino Piccione. The program supports FAA strategic goals for increased safety, greater capacity, and organizational excellence by developing research products and promoting the use of those products to meet the future demands of the aviation system. The program addresses Operational Improvements in the NAS Enterprise Architecture as part of the NextGen Implementation Plan. This research will examine the roles of controllers and maintainers at increased capacity levels and how those roles are best supported by allocation of functions between human operators and automation.

The ATC/TO program generates requirements for human interface characteristics of the next generation of air traffic workstations. It is enhancing our understanding of the role that ATC supervisors play in mitigating operational errors and runway incursions. The program is also providing material to reduce human error incidents associated with the performance of controllers, system maintainers, and others who fill important safety roles. In addition, researchers are determining effective methods to present weather information to air traffic specialists for severe weather avoidance and accident prevention, developing methods to select the next generation of air traffic service providers so that the applicant screening process is valid, reliable, and fair, and improving human-system integration in a manner that allows controllers to manage an increased number of aircraft in a sector while reducing task loading.

The research program works to improve system safety by developing: (1) methods to identify new potential human error problems as the roles and responsibilities of air traffic service providers change as a result of increasing levels of automation; (2) organizational changes to transform the Technical Operations ATO safety culture; (3) effective methods to present weather information to air traffic specialists for accident prevention through severe weather avoidance. Human factors researchers are improving: (1) supervisory best practices so that first-line supervisors can implement effective methods that suppress the rate of operational errors and reduce the severity of errors that do occur; and, (2) methods to select the next generation of air traffic service providers.

The ATC/TO program works to improve the ATC contribution to system capacity by developing: (1) integrated workstations that allow the air traffic service provider to meet the increased demand for services with a reduced staffing level; (2) methods to assess the

value of proposed changes to workstations to determine if human-in-the-loop performance is enhanced to the required level; (3) advanced workstation concepts for staffed virtual towers (introduced by the NextGen Concept of Operations) as a method to use automation to increase services, increase capacity, and decrease the cost of air traffic services. Research results are used to improve: (1) human-system workstation integration in a manner that allows air traffic service providers and pilots to effectively manage traffic loads to efficiently move air traffic in the National Airspace System (NAS); (2) changes in roles and responsibilities between air traffic service providers and pilots as technology evolves to meet future demands.

The Air Traffic Control/Technical Operations Human Factors Research Program provides leadership and products to motivate and inform the evolution of the NAS to assure that the human component of the system will reliably perform to meet the needs of the flying public. Results include: (1) air traffic workstations and concepts that increase productivity of the workforce by identifying key workload factors that must be mitigated to enable the humans in the system to manage the traffic flow in the future NAS; (2) evaluations of candidate technologies that purport to provide a specified human-in-the-loop performance level or safety benefit when used by the ATO workforce; (3) transformation of the ATO safety culture through research in the Technical Operations community to identify effective interventions that are needed to move the ATO toward a Just Culture; (4) personnel selection criteria to enhance the efficiency and effectiveness of the screening process for future air traffic service providers.

The ATC/ATO Human Factors research program receives requirements from its internal FAA sponsoring organizations: Advanced Air Traffic Systems Requirements Group, Individual and Team Performance Requirements Group, Technical Operations Requirements Group, and the Personnel Selection and Training Requirements Group. R&D partnerships have been established with NASA, EUROCONTROL, and ICAO.

Cooperative research grants are in place with Massachusetts Institute of Technology (MIT), St. Louis University, and Texas Tech University.

Listed below are descriptions of FY 2008 ATC/TO research activities.

Air Traffic Control

Human Engineering Program Requirements

Summary: A Human Engineering Program Requirements Standard is being prepared to establish and define requirements for applying human factors to systems, equipment, and facilities acquired by the FAA. This standard will be the primary tasking document used by the FAA to specify human engineering efforts during system acquisition.

Description: A soon-to-be-published Human Engineering Program Requirements Standard will be the primary tasking document used by the FAA to specify human engineering efforts during system acquisition. It will include the work to be accomplished by a contractor or subcontractor in conducting a human engineering effort integrated with the total system engineering effort.

The standard will accommodate a wide range of products, including commercial-off-the-shelf systems, non-developmental systems, and developmental systems. This standard intentionally provides reasonable latitude to apply technical and programmatic judgment and innovation consistent with the nature, size, complexity, and level of human involvement associated with specific acquisitions. It is patterned after the Department of Defense's MIL-HDBK-46855A, and provides a link to the FAA's Human Factors Design Standard and Human Factors Acquisition Job Aid. In addition, some of the potential tools and methodologies for analysis, design, test and evaluation activities can be found in the FAA human factors website workbench.

Air Traffic Control Human Factors – Staffed NextGen Tower Concept

Summary: In today's airport environment, arrival and departure aircraft are controlled using an "out-the-window" paradigm and decision making based on information from several different sources. This generally results in a decrease in the total number of operations during low-visibility and night conditions and necessitates significantly increased controller workloads during those times. To address this issue, the FAA is developing the Staffed NextGen Tower (SNT) concept. SNT will generate a complete suite of integrated tools for controlling and managing departures, arrivals and surface traffic at an airport without the view from the tower cab. Researchers at Volpe Center are preparing for the human-in-the-loop experiments to be conducted at the Airways Facility Tower Integrated Laboratory (AFTIL), FAA Technical Center, Atlantic City, NJ. The experiments are to evaluate different candidate systems for the Staffed NextGen Tower concept.

Description: Airports constitute a major bottleneck in the National Airspace System (NAS). Limiting factors in increasing air traffic levels to and from an airport are the lack of surveillance during night and low-visibility conditions, and the lack of integration of Air Traffic Control Tower (ATCT) systems and functions. Today, arrival and departure aircraft are controlled using an "out-the-window" paradigm and decision making based on information from several different sources. This generally results in a decrease in the total number of operations during low-visibility and night conditions and necessitates significantly increased controller workloads during those times.

To address this issue, the FAA is developing the Staffed NextGen Tower (SNT) concept. SNT is an R&D initiative that will generate a complete suite of integrated tools for controlling and managing departures, arrivals and surface traffic at an airport without the view from the tower cab. SNT eliminates dependencies on out-the-window visual

observations, consolidates information from multiple current sources, and provides additional air traffic flow information to the tower controllers.

In FY2008, research began to evaluate different candidate systems for the SNT concept. Human-in-the-Loop (HITL) experiments to evaluate the different systems will be conducted at the Airways Facility Tower Integrated Laboratory (AFTIL), FAA Technical Center, Atlantic City, NJ. During the evaluation, different candidate SNT systems will be integrated with a tower cab simulator at AFTIL. Retired controllers and pseudo-pilots will participate in several realistic scenarios in AFTIL. All of the runs will be recorded and analyzed. The findings from the scenarios, based on real participants in a realistic environment, will be available by the end of CY2008. These results will provide a basis for further development of SNT.

Runway Incursion Severity Categorization (RISC*)*

Summary/Description: FAA researchers at Booz Allen Hamilton held initial meetings to discuss the scope of work for validation of the Volpe RISC Model and the assessment process. They developed an initial validation approach for the RISC model and timeline. Researchers also met with the Volpe team to establish logic behind the model and determine whether this mimics the logic of the assessment team members. Timelines, deliverables, and methods for validating the model and process were established, and an interview process was started with the data analysis team to clarify and document the runway safety data collection process. A data flow process was established from the runway incursion occurrence to its final entry into the main database. The team continued gathering and evaluating evidence about the degree of validity of the runway incursion severity ratings, and entered and validated a majority of the most severe (Category A and B) runway incursions using the RISC model. During the year, team members attended the weekly runway incursion assessment meetings as part of the validation for the assessment process/team and Runway Incursion Severity Categorization (RISC) model validation.

Controller Displays for Severe Weather Avoidance

Summary: Because of information shortcomings in current en route and TRACON operations, researchers at the William J. Hughes Technical Center are conducting research on weather display concepts for convective activity, ceiling/visibility, and icing information that meet controller needs. In addition to the weather displays, the concept involves an automated support system that tracks GA aircraft and hazardous weather areas. Proposed displays and automation support tools could work towards a reduction in weather-related general aviation accidents and provide information that enhances cockpit decision making.

Description**:** Adverse weather conditions affect flight operations, overall, but are especially hazardous to general aviation (GA) aircraft. The primary weather hazards are

icing, convective activity (i.e., thunderstorms), and reductions in ceiling/visibility. Because of information shortcomings in current en route and TRACON operations, this research proposes weather display concepts for convective activity, ceiling/visibility, and icing information that meet controller needs.

In addition to the weather displays, our concept involves an automated support system that tracks GA aircraft and hazardous weather areas. When the automated system detects a future conflict with an aircraft and a hazardous weather region, the system alerts the controller about the aircraft and the hazard. Our proposed displays and automation support tool could work towards a reduction in weather-related GA accidents and provide information that enhances cockpit decision making.

En Route Information Display System (ERIDS) Analyses

Summary**:** ERIDS is an interactive, real-time electronic information display system that was developed to replace the Air Traffic Control (ATC) information system that consisted mostly of paper sources of information. In 2008, researchers collected data on the usage and benefits of fielded ERIDS in comparison to usage before it was implemented. Results indicated that some types of information were easier to access in ERIDS, but others were not. Data maintenance requires less labor hours with ERIDS. A number of human factors issues and potential solutions with the system that could improve its usability were identified.

Description**:** ERIDS is part of the FAA En Route Automation Modernization plan to replace legacy computers and backup systems. ERIDS is an interactive, real-time electronic information display system that was developed to replace the Air Traffic Control (ATC) information system that consisted mostly of paper sources of information. ERIDS provides controllers, supervisors, and traffic management experts with electronic access to aeronautical data, airspace charts, ATC procedures documents, Notices to Airmen, location identifiers, and other sources of ATC information. Previous analyses of a prototype ERIDS deployed at Air Route Traffic Control Centers (ARTCCs) found that accessing some types of information was faster with ERIDS but not for all types of information. However, the paper documents were readily available during the assessment, and that is not always the case in actual operations. Although there were initial labor costs to set up ERIDS, the costs of ongoing maintenance of the databases were reduced. In 2008, researchers collected data on the usage and benefits of fielded ERIDS in comparison to usage before it was implemented. The pre-deployment data collection was conducted in FY2007.

In this year's research effort, the team conducted the post-deployment data collection at one ARTCC where pre-deployment data were collected. The same research protocols were used as in the pre-deployment effort. Controllers were observed during live operations and their use of ERIDS was documented. Simulations were conducted to examine how quickly controllers access different types of ATC information using ERIDS. Questionnaires were administered to investigate controllers' use of reference materials in ERIDS. Finally, facility personnel who update, distribute, and dispose of

reference materials in the paper system and in ERIDS were interviewed. The results were similar to the prototype ERIDS analyses. Controllers did not access information in ERIDS very frequently. Some types of information were easier to access in ERIDS, but others were not. Data maintenance requires less labor hours with ERIDS. A number of human factors issues and potential solutions with the system that could improve its usability were identified.

Electronic Flight Data Handling for Airport Traffic Control Towers

Summary: Human factors researchers designed two prototype electronic flight data interfaces (EFDIs) for use in Airport Traffic Control Towers. These EFDIs address the role of electronic flight data, System Wide Information Management, and the Staffed NextGen Tower (SNT) concepts in NextGen. The team conducted formal usability testing to identify any remaining problems and to ensure that actual users could operate the prototypes effectively. In addition, researchers compared the Tower Operations Digital Data System (TODDS) to paper Flight Progress Strips in a zero visibility operation and collected additional usability data on TODDS and on controllers' ability to use the touch screen hardware

Description**:** Human factors researchers designed two prototype electronic flight data interfaces (EFDIs) for use in Airport Traffic Control Towers. These EFDIs address the role of electronic flight data, System Wide Information Management, and the Staffed NextGen Tower (SNT) concepts in NextGen. The Integrated EFDI combines EFD with a surface surveillance capability. The Perceptual-Spatial EFDI does not use surface surveillance capability, but provides a way for controllers to spatially organize EFD using a surface map of an airport.

Once the initial prototypes were functional, researchers conducted formal usability testing to identify any remaining problems and to ensure that actual users could operate the prototypes effectively. The initial usability test provided data that enabled researchers to refine the EFDIs and expand their scope into the current Tower Operations Digital Data System (TODDS). In addition to making the most difficult features easier to use, TODDS adds the ability for controllers to issue digital taxi out clearances, perform taxi conformance monitoring, indicate closed runway and taxiway segments, and access integrated weather information including advisories for wake turbulence separation.

Researchers compared TODDS to paper Flight Progress Strips (FPSs) in a zero visibility ATCT operation. They also collected additional usability data on TODDS and assessed controllers' ability to use the touch screen hardware.

Future En Route Workstation (FEWS) III Simulation

Summary**:** The FEWS III simulation will investigate concepts that are designed to increase airspace capacity without negatively affecting controller workload and performance. The concepts are based on plans developed by NextGen, and include the increased use of Area Navigation (RNAV) routes and the delegation of some procedures

(e.g., self-spacing) to the flight deck. The FEWS III simulation will also include a procedure to enable two or more aircraft to be controlled as a single unit, similar to the way that controllers currently manage military aircraft in formation flight.

Description: The FEWS III simulation will investigate concepts that are designed to increase airspace capacity without negatively affecting controller workload and performance. The concepts are based on plans developed by the Next Generation Air Traffic System (NextGen) and include the increased use of Area Navigation (RNAV) routes and the delegation of some procedures (e.g., self-spacing) to the flight deck. The FEWS III simulation will also include a procedure to enable two or more aircraft to be controlled as a single unit, similar to the way that controllers currently manage military aircraft in formation flight. Aircraft that are conducting these procedures may require less controller intervention than those requiring conventional control. This may result in fewer air/ground communications and an increase in the number of aircraft that can be handled in the sector.

Previous FEWS simulations evaluated modifications to the controller workstation to support the management of increased traffic levels. The goal of the modifications is to make information available to the controller when it is needed and to reduce the number of "housekeeping" tasks (e.g., data block management) that the controller must perform. Results of the earlier simulations found benefits for the FEWS interface, including better situational awareness, less workload, less display complexity, better sequencing air traffic, and fewer controller data entries.

For the FEWS III simulation, additional modifications will be made to the controller workstation to support use of the RNAV, self-spacing, and aircraft grouping procedures. Researchers will evaluate aircraft and controller performance and efficiency measures at air traffic levels anticipated for 2015 and beyond. Three-mile lateral separation standards will be used under the assumption that advanced surveillance capabilities will be in place. The evaluation will be conducted using a simulated En Route Automation Modernization (ERAM) system, planned to replace the current Display System Replacement (DSR) by 2010, and FEWS. The concepts will be tested in optimal and suboptimal (e.g., weather) conditions. Researchers are conducting shakedown activities in preparation for the simulation that will be completed in February, 2009.

Air Traffic Control Display Standard – Terminal Color

Summary: The ATC Display Standard project seeks to develop human factors standards that are specific to ATC and provide very detailed guidance for the most important ATC display elements. This phase of the project seeks to develop a standard terminal color palette that: (1) follows human factors guidelines and best practices, (2) considers the operational, procedural, and environmental factors of ATC, (3) is specific with regard to display elements and color values, and (4) provides standards that can be directly implemented by system developers.

Description**:** The FAA *Human Factors Design Standard* contains many standards that can be used to develop user interfaces that are easy to learn, efficient to use, and reduce

the likelihood of human error. However, the HFDS standards are not specific to ATC tasks and systems, and may not be detailed enough for ATC system developers to implement directly. The ATC Display Standard project seeks to develop human factors standards that are specific to ATC and provide very detailed guidance for the most important ATC display elements.

In the case of color on ATC displays, current programs individually choose their colors. The chosen colors do not always conform to human factors best practices and are often inconsistent across systems. These issues decrease the usability of terminal systems overall, increase the likelihood of human error, and increase training requirements. In addition, resources are spent redundantly when each program develops its own color requirements and designs. Existing FAA and industry color standards provide overall guidance. However, the standards do not specify which colors should be used for which ATC display elements. Existing standards also do not provide detailed color values expressed in hardware-independent terms. These limitations make the existing color standards difficult for system developers to use. This phase of the ATC Display Standard project seeks to develop a standard terminal color palette that (1) follows human factors guidelines and best practices, (2) considers the operational, procedural, and environmental factors of ATC, (3) is specific with regard to display elements and color values, and (4) provides standards that can be directly implemented by system developers.

The colors used on the Standard Terminal Automation Replacement System (STARS) and the Common Automated Radar Terminal System (CARTS) were measured on four different monitors. The measurements allowed us to compare the current colors to human factors standards and guidelines. We considered factors such as text readability, the ability of colors to draw attention, how easily colors can be identified and named, and how easily two similar colors can be discriminated from each other. Where we identified deficiencies with the current colors, we proposed alternative colors that better meet human factors guidelines.

The project created a standard color palette for terminal ATC systems that describes each display element (e.g., data blocks, targets, maps) and specifies a color for that element. The specified colors are expressed in hardware-independent coordinates. To assist programs in implementing the colors, we also provide hardware-specific coordinates for several existing monitors.

Air Traffic Control Display Standard – Target Symbology

Summary: Targets are the symbols on ATC displays that show aircraft positions and related data. As symbols become more complex and incorporate more information, the potential for confusion or human error increases. Researchers at the William J. Hughes Technical Center are reevaluating target symbols to ensure that they provide the most important ATC information in the most effective way.

Description**:** This project is the second in the ATC Display Standard series. Targets are the symbols on ATC displays that show aircraft positions and related data. Different ATC systems depict targets differently, and some symbols reflect the limitations of legacy graphics technology rather than good human factors design. Now that those limitations are largely gone, we have an opportunity to reevaluate target symbols to ensure that they provide the most important ATC information in the most effective way. For example, some current target symbols create perceptual effects where controllers may misread the symbol and obtain a wrong impression of aircraft positions or directions. Symbols used in other domains, such as cockpit displays and military systems, may provide useful lessons about effective target symbol design. Furthermore, new ATC technology and procedures may mandate changes to target symbols in the near future. As symbols become more complex and incorporate more information, the potential for confusion or human error increases.

Researchers conducted a literature search and analysis to examine current target symbols. The literature search examined symbols used in other domains and with other characteristics to determine if alternative symbols may be beneficial to ATC. The team has examined human factors research, FAA and foreign ATC systems, cockpit displays, and military systems. They have also analyzed the information requirements of targets to determine which information should be provided by the target (e.g., location, direction of flight, aircraft type) and analyzed which display techniques (e.g., shape, color, size) most effectively convey that information. Once potentially beneficial alternative symbols are identified, they will examine these in a part-task study. The results of the study may be eventually incorporated into other ongoing human-in-the-loop simulation projects and ultimately into requirements for operational systems. The project will produce a standard document describing target symbols for ATC systems. The chosen symbols will be supported by human factors research and best practices, and will account for the operational requirements of ATC.

Future Terminal Workstation (FTWS)

Summary: The objective of the Future Terminal Workstation (FTWS) project is to create a prototype workstation for the terminal domain that incorporates the technology needed to support NextGen. The prototype will be used to conduct human factors research on NextGen operational concepts and procedures to determine their effect on controller performance, decision-making, and workload, and how the information necessary to support NextGen in the terminal domain can be best presented and integrated onto the controller workstation.

Description**:** NextGen will bring substantial changes to terminal airspace in 2015-2025. However, it is not known how the NextGen operational concepts, procedures, and technology, combined with higher traffic complexity, will affect controller performance, decision-making, or workload. It is also not known how the information necessary to support NextGen in the terminal domain can be best presented and integrated onto the controller workstation.

The objective of the Future Terminal Workstation (FTWS) project is to create a prototype workstation for the terminal domain that incorporates the technology needed to support NextGen, and then use the prototype to conduct human factors research on NextGen operational concepts and procedures. The prototype will be designed to follow human factors best practices, keep controller workload at manageable levels, and reduce the likelihood for human error. The prototype will build on research and designs created for other projects, and lessons learned from other systems, domains, and countries. In FY08, we created the FTWS prototype and accompanying traffic scenarios. The prototype and scenarios will serve as the platform for human-in-the-loop simulations in FY09-FY11.

Research is directed at developing the FTWS platform using the Distributed Environment for Simulation, Rapid Engineering, and Experimentation (DESIREE). FTWS will consist of several user interface "skins" that include different display designs and capabilities. One skin will reflect the current Standard Terminal Automation Replacement System (STARS). The second skin will reflect STARS with several important new capabilities added, including Automatic Dependent Surveillance Broadcast (ADS-B) and controller-pilot Data Communications (DataComm). The third skin will bring advanced user interface capabilities designed by other projects in the laboratory.

Researchers will conduct three human-in-the-loop simulations over the next four years examining various human factors issues related to future terminal operations. We expect to deliver reports and briefings following each simulation.

Separation Management Project

Summary: The Separation Management Project is a multi-year project to demonstrate, validate, and establish automation requirements for separation management in the en route environment.

Description**:** In the NextGen concept of operations, separation management will incorporate new air traffic control technologies, automation, and procedures and accommodate new aircraft equipment, capabilities, and types. The Separation Management Project is a multi-year project to demonstrate, validate, and establish automation requirements for separation management in the en route environment.

Researchers visited field facilities to gather information about separation management procedures that are currently being used. They conducted a cognitive walkthrough with subject matter experts to identify information requirements for separation management in different air traffic control situations. They organized subject matter expert comments and selected several separation management concepts for implementation in the laboratory air traffic control simulator. In the coming months, they will conduct a concepts demonstration with subject matter experts using the simulator. In the next year, they will conduct a human-in-the-loop simulation testing the concepts and tools that have been developed.

Traffic Flow Management System (TFMS)

Summary: The TFMS delivers information about all flights in the US to the Air Traffic Control System Command Center, the en route centers, major terminal and tower facilities, the airlines, the military and other organizations. These organizations use tools such as the Traffic Situation Display (TSD) and the Flight Schedule Monitor (FSM) to manage the flow of air traffic within the NAS. In 2008, human factors researchers supported development of a Reroute Impact Assessment capability, developed requirements for the redesign of displays based on usability data, and conducted a Human Factors Review of Integrated Program Modeling.

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In FY08, human factors researchers continued providing the ongoing support. In particular, we supported development of a Reroute Impact Assessment capability, developed requirements for the redesign of displays based on usability data, and conducted a Human Factors Review of Integrated Program Modeling.

Researchers participated on multidisciplinary teams and provided human factors guidance in the design of system displays. They investigated current procedures and tools to gain an understanding of the Traffic Management Specialists' mental model. They observed the users while they exercised systems in the operational and laboratory environments, and identified usability issues. They reviewed proposed designs and worked with the vendor to ensure compliance with established design guidelines and standards. They also assessed benefits to the users of new capabilities and improved designs.

Flight Strip Scanner Use with the Departure Spacing Program at Air Traffic Control Towers

Summary: The Departure Spacing Program (DSP) tool is in use at seven air traffic control towers (ATCTs) in the New York area. One of the data entry methods available in DSP is scanning flight strip barcodes with a flight strip scanner. Human factors researchers investigated the use of these scanners and the differences in operations between facilities that may make one type of scanner more effective than another.

Description: The Departure Spacing Program (DSP) tool is in use at seven air traffic control towers (ATCTs) in the New York area. One of the data entry methods available in DSP is scanning flight strip barcodes with a flight strip scanner. Human factors researchers investigated the use of these scanners and the differences in operations between facilities that may make one type of scanner more effective than another.

The research team visited four DSP ATCTs. They observed operations and interviewed controllers about their use of the DSP flight strip scanners. The interviews focused on the types of scanners used, the conditions that make one type of scanner more (or less) effective, and any problems experienced with the scanners. Based on observations and controller reports, two factors influence scanner use at ATCTs: the physical size of the ATCT and the volume of traffic handled by the facility. Smaller ATCTs have limited work surfaces and benefit when the scanners are mounted elsewhere (e.g., on the sloped surfaces of the consoles). Larger facilities have more work surfaces and, based on operational need or controller preference, may need to move the scanner.

Though use of the gun-style scanner was reported to be infrequent, the ability to scan multiple strips in rapid succession appears useful, especially during busy, high volume operations. Reported technical difficulties may be contributing to the limited use of these scanners. We recommend that future scanners continue to provide this "aim and shoot" capability and that scanner placement and cord length be considered carefully.

National Traffic Management Log

Summary: The FAA developed the National Traffic Management Log (NTML) to electronically log, coordinate, and communicate Traffic Management Initiative information among Air Traffic Control facilities and the Command Center. Human factors researchers supported development of the NTML by evaluating information requirements, prototyping visual displays, conducting usability assessments, and assessing benefits to human performance of planned enhancements. A new development titled Electronic Coordination Capability will allow Traffic Managers at affected facilities and the Command Center to monitor and respond to flight restriction TMIs electronically, eliminating the need for telephone coordination for the majority of TMI requests. Human factors researchers worked with a multidisciplinary team to identify information and display requirements for this new tool. They developed prototypes and evaluated them through cognitive walk-throughs with the users, and validated the design with human-in-the-loop testing.

Description: Federal regulations require Traffic Managers to maintain a record of Traffic Management Initiatives (TMIs), to coordinate the implementation of some TMIs with the Air Traffic Control System Command Center, and to communicate TMI information to Traffic Managers at all affected facilities as well as to the controllers within their own facility. The FAA developed the National Traffic Management Log (NTML) to electronically log, coordinate, and communicate TMI information among Air Traffic Control facilities and the Command Center. In the past, human factors researchers supported development of the NTML by evaluating information requirements, prototyping visual displays, conducting usability assessments, and assessing benefits to human performance of planned enhancements. In FY08 we continued providing the ongoing support. One of the new capabilities developed and deployed in FY08 was Electronic Coordination.

The introduction of the NTML did not eliminate the need for coordination calls among facilities. In the first quarter of 2006, for example, more than 54,000 flight restriction TMIs were processed system wide using the NTML, requiring approximately 85,000

coordination telephone calls. The impact of this volume of telephone calls is significant, particularly in the complex, dynamic environment of a Traffic Management Unit (TMU). The Electronic Coordination capability will allow Traffic Managers at affected facilities and the Command Center to monitor and respond to flight restriction TMIs electronically, eliminating the need for telephone coordination for the majority of TMI requests.

As with other NTML enhancements, researchers worked with a multidisciplinary team to identify information and display requirements. They developed prototypes and evaluated them through cognitive walk-throughs with the users, and validated the design with human-in-the-loop testing.

Traffic Flow Management - Modernization

Summary: The Traffic Flow Management Modernization program will replace the Enhanced Traffic Management System. Researchers applied human factors techniques in support of various development efforts and provided guidance in system design decisions.

Description**:** The Traffic Flow Management Modernization (TFM-M) program will replace the Enhanced Traffic Management System. We applied human factors techniques in support of various development efforts and provided guidance in system design decisions. The following work was accomplished:

• Analyzed current use of the Common Constraint Situation Display (CCSD) and the Web Situation Display (WSD); identified the functions that are used frequently and significant system and usability issues.

• Conducted a feasibility study for using the graphical user interface for TFM-M Post Operational Reporting to accomplish the majority of Command Line commands.

• Conducted a study of the operational use of multi-headed workstations to assess operational needs for glass space and provided recommendations for hardware selection.

TFM-M and the design decisions made during development.

• Reviewed prototypes of future concepts and provided feedback to the developer on their feasibility and design.

National Airspace System Voice Switch (NVS) Human Factors Support

Summary: Voice switches are the equipment controllers use to interact with air-ground radios, telephones, and intercoms. Controllers communicate via voice with pilots, other controllers, and other facilities. The National Airspace System Voice Switch (NVS) will replace various aging voice switches at en route, approach control, and tower facilities. The NVS system architecture and technical capabilities will be considerably different from the current switches. The NVS may also bring some changes to the user interfaces and to characteristics of the voice signal itself. Human factors researchers are examining the possible effects of these changes on controllers.

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Researchers are providing consulting to the NVS program office in the areas of user interface design and evaluation, and in conducting assessments of potential human factors issues. In 2008, they examined existing requirements for two legacy voice switches and identified human factors related items. In collaboration with engineers from the program office, they consolidated the human factors requirements, eliminated redundancies, and updated the requirements to reflect recent research and best practices. The team also added human factors requirements based on FAA and industry standards. In addition, researchers prepared a human factors assessment examining the effects of different Voice Over Internet Protocol (VoIP) technologies on speech intelligibility. The study will use established human factors protocols and will examine the potential effects on regular speech and speech specific to ATC operations.

Airport Traffic Control Tower Simulation Infrastructure Development

Summary: This project seeks to extend the existing FAA-owned ATC simulation capability to create an Airport Traffic Control Tower (ATCT) simulation capability. The ATCT simulation infrastructure will support research on concepts such as the Staffed NextGen Tower, digital data communications, and integrated ATCT information displays. The ATCT simulator will also have the ability to integrate with existing simulation capabilities to enable end-to-end simulation that encompasses ATCT, terminal, and en route airspace.

Description**:** Numerous air traffic control (ATC) simulators have been developed and marketed. However, the vast majority of ATC simulators are proprietary products developed for simulation and training purposes rather than concept research. The proprietary nature of existing ATC simulators renders them inflexible, expensive, and limited in capabilities regarding rapid prototyping and data collection.

The current project seeks to extend the existing FAA owned ATC simulation capability supported by the Distributed Environment for Simulation, Rapid Engineering, and Experimentation (DESIREE) and the Target Generation Facility located at the William J. Hughes Technical Center to create an Airport Traffic Control Tower (ATCT) simulation capability. The ATCT simulation infrastructure will support research on concepts such as the Staffed NextGen Tower, digital data communications, and integrated ATCT information displays. The ATCT simulator will also have the ability to integrate with

existing simulation capabilities to enable end-to-end simulation that encompasses ATCT, terminal, and en route airspace.

Powered Air Purifying Respirator Feasibility Study

Summary: Respiratory protection is one of the tools that the FAA may use to minimize the spread of disease among staff that cannot function remotely in times of national emergency. Researchers at the William J. Hughes Technical Center conducted a study to assess the feasibility of conducting maintainer and ATC-type tasks while wearing respirators

Description: Safe and efficient movement of air traffic is particularly important to the nation's air transportation system in times of national emergency. In the event of a pandemic flu, the FAA will deploy many tools to minimize spread of the disease among its workforce and to maintain National Airspace System operations. Some members of the FAA staff may telecommute; others will be engaged in tasks that cannot be accomplished remotely. Air traffic control can only be accomplished at Air Traffic Control (ATC) facilities. Respiratory protection is one of the tools that the FAA may use to minimize the spread of disease among staff that cannot function remotely. Two styles of respirators have been proposed: Powered Air Purifying Respirators (PAPRs) for air traffic controllers and N95 half-face masks for Technical Operations personnel. Researchers conducted a study to assess the feasibility of conducting maintainer and ATC-type tasks while wearing respirators.

The research method consisted of two phases, an initial usability assessment of different respirator styles and models, followed by an experimental evaluation of user performance. During the usability assessment, researchers measured characteristics such as the noise level created by the PAPR blower and the weight of the equipment. They also evaluated the use of other equipment such as telephones and binoculars. During the experimental evaluation, they measured human performance in part-task analyses. The tasks were representative of air traffic controller tasks and technical operations maintenance tasks. Speech intelligibility and visual performance with three PAPR models were measured, and speech intelligibility and performance of maintenance tasks with three N95 models were measured. Researchers also collected subjective data from the participants about their comfort and well-being over time. Detailed data analyses are in progress.

Longitudinal Validation of ATC Selection Instruments: Assessment of Cognitive Aptitude

Summary: An analysis was conducted to assess validity of the Air Traffic Selection and Training (AT-SAT) selection test battery when selecting Air Navigation Service Providers for the NextGen system. AT-SAT was shown to correctly predict outcomes for 73.5% of the trainees. Thus, the use of AT-SAT as a selection instrument has additional support.

Description: CAMI tested 72 Academy ATC classes (1,069 students). One purpose of the testing was to obtain biographical information about incoming ATC students. Another purpose was to obtain information relevant to the longitudinal validation of the Air Traffic Selection and Training (AT-SAT) selection test battery. In addition, researchers needed to assess, in an experimental setting, the effectiveness of new tests that might be used to replace AT-SAT subtests when selecting Air Navigation Service Providers (ANSPs) for the NextGen system. This will be important if we learn that the job of the ANSP is sufficiently different from today's ATC Specialist job to require changes to selection requirements.

An analysis was conducted to assess validity of AT-SAT in predicting Performance Verification (PV) outcomes. AT-SAT data and PV outcomes were compared for six hundred fifty applicants who took AT-SAT as part of the hiring process and completed initial training at the FAA Academy. Using logistic regression on a subset, AT-SAT was shown to correctly predict PV outcomes for 73.5% of the trainees. Thus, the use of AT-SAT as a selection instrument has additional support.

Development of Methods to Assess Applicant Temperament and Emotional Stability

Summary: CAMI personnel were instrumental in replacing the 16PF, a psychological screening test for ATC Specialist applicants, with the MMPI-2, a new test for screening Air Traffic Control Specialists. Based on research conducted at CAMI, the MMPI-2 was found to be a more sensitive indicator of potential psychopathology.

Description: CAMI personnel were instrumental in replacing the 16PF, a psychological screening test for ATC Specialist applicants, with the MMPI-2 in FY08. This involved developing plans for administering and scoring the MMPI-2, identifying a set of scales and cutoff scores to be used to refer unsuccessful applicants for further testing, developing letters to both notify applicants who will be required to undergo additional assessment before they can be medically cleared, and to inform psychologists about the procedures they should use when conducting the second tier testing. Coordination also occurred with FAA headquarters to identify their role in the administration and interpretation of MMPI-2 results and to provide feedback to applicants who do not pass.

CAMI personnel also established procedures for collecting test data on personal computers and transmitting the results in a secure fashion over the internet. In support of this effort, they: (1) worked with ATO Information Technology personnel to define security needs to ensure secure administration of the MMPI-2 at every FAA facility; (2) arranged with Pearson Assessments, owners of the MMPI-2, to place the software on an FAA server; (3) pilot tested the software multiple times with several groups of pseudo-applicants to be sure it worked and ensure the security of the data transmission; (4) and established a procedure for applicants to take the test locally, then upload the responses so they could be scored at a centralized location.

Researchers provided assistance to ATO-A with efforts to incorporate the MMPI-2 in the Pre-Employment Processing Center (PEPC) concept that allowed rapid processing of application data from candidate air traffic controllers. The research team traveled to the first PEPC in each region, ensuring that MMPI-2 testing was conducted successfully, and interacted with the Regional Flight Surgeons to ensure that they understood how to conduct second-tier testing. Finally, researchers reviewed the psychological tests submitted by candidates who failed the MMPI-2.

Evaluation of ATCS Biographical Data and Interview Selection Procedures

Summary: CAMI personnel developed a structured interview process to use for ATC Specialist applicants. Interviews are conducted by facility managers after a centralized selection panel has made a tentative job offer. The interview is used to make a placement decision, based on past experience, and assess candidate suitability for the job

Description: CAMI personnel developed a structured interview process to use for ATC Specialist applicants. Interviews are conducted by facility managers after a centralized selection panel has made a tentative job offer. The interview is used to make a placement decision, based on past experience, and assess candidate suitability for the job. The interview process was accepted by ATO-A and operational use began. Follow-up will occur to determine that the process is being used properly.

Researchers developed a biographical inventory called the CAMI Life Experiences Questionnaire (CLEQ). The purpose of the CLEQ is to identify candidates who are likely to pass the AT-SAT selection battery so they can be targeted to take AT-SAT. As the cost of taking AT-SAT is about $800 per person, not everyone who expresses interest can be allowed to take the test. Prior to implementation of the CLEQ, candidates were randomly selected to take AT-SAT, so use of the CLEQ improved the selection process. A shortened, empirically-keyed, response-option scored biographical data instrument will be available in 2009.

Researchers examined applicants' reactions to the ATC Specialist selection process. Several focus groups were held with newly hired controllers during CAMI research testing sessions. Issues identified by the new controllers about the hiring process were summarized and reported as an interim product.

Concurrent Validation of AT-SAT for Placement

Summary: CAMI continued participation in an effort to demonstrate the validity of the AT-SAT selection battery for predicting job performance of tower controllers.

Description: CAMI continued participation in an effort to demonstrate the validity of the AT-SAT selection battery for predicting job performance of tower controllers. Validation

for the tower job will allow AT-SAT scores to be used to place applicants into different types or levels of facilities. In FY08, the research team used the updated job/task analysis and worked with tower control instructor subject matter experts at the FAA Academy to develop 51 performance measurement scenarios and 173 question items for use in the collection of criterion data.

Develop New Practical Color Vision Tests for ATCS Applicants

Summary: CAMI researchers developed a new practical color vision test for selection of air traffic controllers to ensure that those selected have adequate color vision to be able to operate the color displays in ATC facilities.

Description: CAMI researchers developed a new practical color vision test for selection of air traffic controllers to ensure that those selected have adequate color vision to be able to operate the color displays used extensively in ATC facilities today.

The Air Traffic Color Vision Test (ATCOV) was developed in FY07, and was validated for operational use in FY08. The ATCOV validation consisted of two studies. The first tested 81 color vision deficient and 152 color-normal subjects. This study provided information about ATCOV's validity, reliability, and standardization. The validation empirically indicates that, with selected cut-off scores, ATCOV exhibits high specificity and sensitivity. Approximately 7% of color vision deficient applicants are expected to pass ATCOV, as they will perform as well as 95% of the normal population. ATCOV was demonstrated to be highly reliable, uncorrelated with cognitive ability. It can be self-administrated or instructor-administrated with minor training of proctors.

Strategic Job Analysis - Selecting the Controller of the Future

Summary: CAMI researchers are conducting a strategic job analysis (SJA) that describes the new roles of Air Navigation Service Providers with the evolving NextGen concepts of operations, technologies, and procedures. The SJA will identify new or changed requirements linked to NextGen and develop specifications for assessment of those requirements.

Description: CAMI researchers are conducting a strategic job analysis (SJA) that describes the new roles of Air Navigation Service Providers (ANSP). As NextGen evolves, ANSPs will use a highly automated system, sharing separation responsibilities with pilots, and moving toward performance-based services. In parallel with evolving NextGen concepts of operations, technologies, and procedures, the SJA will identify new or changed knowledge and skill requirements, and develop specifications for assessment of those requirements to ensure that future ANSPs will be able to fulfill new or changed roles and responsibilities in the NAS by 2025. The first step toward accomplishing this goal is to develop a prototype Job Analysis Information Database (JAIdB). In FY08, existing sources of ATC Specialist job/task analysis information are being identified,

assessed, and integrated. Specifically, the AIR and CTA-SACHA lists are being compared and integrated at the Activity, Sub-activity, and Task levels of description, starting with the air traffic control tower cab.

The second step is to identify NextGen initiatives for analysis. Gaining access to the appropriate NextGen managers and development teams is an on-going challenge but is critical to the success of the SJA effort. To date, the team responsible for the optimized descent profiles demonstration project over the summer of 2008 has been most responsive and collaborative.

ATC Safety Risk Assessment Analysis

Summary: CAMI researchers conducted a study to assess the probability that an ATC Operational Error will occur by taking into account the amount of time actually spent on position during normal operations. Without other variables, the overall cumulative probability is very low, .05%.

Description: CAMI researchers conducted a study to assess the probability that an ATC Operational Error (OE) will occur based on: (1) exposure to daily activities while working on a given shift at a particular time of day, and (2) the amount of time spent on position. In the past, most information about OEs was based only on their frequency of occurrence under various conditions. Data recently became available that allowed conducting analyses that take into account the amount of time actually spent on position during normal operations. The probability distribution of an OE occurring based on the number of "sign ins-sign-outs" that occur within 10 minute time intervals was computed for six en route centers having the largest number of OEs during CY 2006. The probability of an OE occurring within any given 10 minute interval ranged from .002% (at the 90 min. interval) to .006% (at > 120 min. interval), resulting in an overall cumulative probability of .05%.

Flight Strip Studies

Summary: CAMI researchers worked to understand the information needs of controllers in order to allow designers to develop displays that not only present the types of information that are needed, but that also adapt to enable information to be available under the appropriate conditions.

Description: CAMI personnel worked with faculty and students from Texas Tech University on a project to understand how, why, and when tower controllers use information. Understanding the information needs of controllers will allow designers to develop displays that not only present the types of information that are needed, but that also adapt to enable information to be available under the appropriate conditions.

Quantifying the relevance of information can be helpful in effective display design. Three reports were produced. The first, on the use of flight progress strips, is available form the International Journal of Aviation Psychology. The second report showed that the information objects of highest relevance for each position were Air Traffic Information Service message for FD/CD, and primary target for both Ground and Local Control. When looking at the information objects with maximum relevance scores, it is apparent that the large majority of those information objects above one standard deviation were weather related. The third report showed, among other things, that during a runway closure, ground controllers need more aircraft identification information, and during an aircraft malfunction, local controllers need more aircraft type information.

Development and Support of a Human Factors Concept of Operations

Summary: CAMI personnel initiated a project to develop a human factors-driven Concept of Operations (ConOps) that will provide designers with the knowledge needed to develop a new air traffic control system capable of accommodating greater amounts of air traffic while also maintaining or increasing air traffic safety levels above those of today.

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In support of this effort, researchers conducted two independent studies in parallel. Both relied on an updated hierarchical job/task analysis of en route air traffic control. The first study reviewed the current JPDO ConOps, the OEP solution sets, and studies associated with the ConOps that have been performed by MITRE to determine how each air traffic control function included in the task analysis is allocated in NextGen. The second study used knowledge of human factors and cognitive psychology literature to identify the relevant issues associated with each function. The two matrices that resulted from these studies have been used to identify inconsistencies and problem areas and suggest whether human factors research can be conducted to fill in any identified gaps. In addition, CAMI personnel conducted a feasibility study to identify a draft set of factors/events to include in scenarios against which ConOps solutions can be tested. This will show the extent of solution benefits and reveal situations where ConOps solutions need to be improved or extended.

Tower External Visual Requirements

Summary: CAMI researchers are examining eye-movement and visual air traffic control information found external to the ATC tower cab to support development of virtual tower displays.

Description: Data regarding visual air traffic control information found external to the tower cab are needed to support the development of virtual tower displays. Developers of new displays need to know what information to provide to remote controllers working at virtual towers, where that information can be found, and when controllers will need access to it. CAMI researchers are conducting a study to identify external information requirements for tower controllers. The plan is to collect eye-movement and external visual information requirements data during both civilian air traffic tower control simulations and live operations at Navy air traffic towers. Additional analysis of eye-movement patterns will be conducted and will result in the publication of a preliminary external visual information requirements document.

ATC Information Complexity

Summary: Research is being conducted to measure information complexity and assess the effects that the design of new ATC displays may have on controller performance and workload. Results argue against the philosophy that operators can learn to effectively and efficiently use information provided by technology simply by practicing. A different experiment found that, even when individuals easily learned the meaning of information presented in a data block with simple paper-pencil training, when required to monitor multiple data blocks presented on a computer screen for a sustained period of time, they only achieved an average of 50-60% accurate performance in this seemingly simple task. Overall, de-complexity might be needed to improve performance effectiveness on monitoring tasks.

Description: Human factors researchers developed two questionnaires to measure information complexity associated with ATC displays. It is necessary to measure information complexity to assess the effects that the design of new ATC displays may have on controller performance and workload.

Several studies were conducted for this project. One study investigated whether training could aid individuals in improving their performance on a task that involved monitoring the status of data blocks. The results suggested that performance improvement was constrained by several factors: the complexity of the data block, the types of information included in the data block, the time that subjects spend on the tasks, and the ways in which subjects used the information. These results argue against the philosophy that operators can learn to effectively and efficiently use information provided by technology simply by practicing.

A different experiment found that, even when individuals easily learned the meaning of information presented in a data block with simple paper-pencil training, when required to monitor multiple data blocks presented on a computer screen for a sustained period of time, they only achieved an average of 50-60% accurate performance in this seemingly simple task. Moreover, there was no improvement in this type of monitoring performance when more practice trials were provided. The results suggested that training on

monitoring strategies including de-complexity might be needed to improve performance effectiveness on monitoring tasks.

Dynamic Comprehension: Time on Position and Mental Fatigue

Summary**:** Human factors researchers are examining the minimum amount of time a controller needs to develop situation awareness following a position transfer, and the maximum amount of time a controller can be on position before suffering a loss of situation awareness due to mental fatigue.

Description: CAMI researchers began a series of studies to allow them to determine the minimum amount of time a controller needs to develop situation awareness following a position transfer, and the maximum amount of time a controller can be on position before suffering a loss of dynamic comprehension due to mental fatigue. An initial study was conducted to determine whether two measures of situation awareness (objective oculometer measures and subjective ratings) could measure changes as the difficulty of a scenario changes. The results suggested that variation in task performance likely to be related to situation awareness was correlated with variation in ratings. Future analyses will investigate whether changes in the oculometer measures are also related to changes in situation awareness.

Validating the Skills Evaluation Rating Form used for Air Traffic Controller Specialists

Summary: FAA-funded human factors researchers at the American Institutes for Research (AIR) are working to conduct a concurrent criterion-related validity study of the AT-SAT battery for the selection and classification of air traffic control specialists (ATCSs) in the Tower Option. Although a performance measurement instrument is being developed specifically for this project, there is a need for an additional validated tool for measuring the "over-the-shoulder" performance. Although the FAA Form 3120.25 was designed for this purpose, a formal validation evaluation has not been conducted on this instrument. Once validated (and modified if necessary), the form will be used in conjunction with additional measures of performance. In June of 2008, AIR began assessing the validity of this form. This evaluation will allow for an analysis of the job-relatedness of the current Skills Evaluation Form, for modifications to the tool to allow the form to meet the 1978 *Uniform Guidelines on Employee Selection* (if modifications are required), and for an evaluation of the reliability of the revised tool. To date, AIR has developed a detailed research plan for achieving the objective of this project and has worked with FAA sponsors to identify and schedule subject matter experts (SMEs) to participate in the evaluation activities.

Description: AIR conducted a review of the current processes and practices for evaluating controller performance using the Skills Evaluation Form in all three ATCS job options (i.e., Tower, TRACON, and ARTCC). AIR also met with FAA sponsors (AHR-4

and AOV) and other stakeholders (e.g., ATO-T, ATO-E) to discuss project details including the availability of SMEs, and the processes required to gain access to these SMEs including communication with the National Air Traffic Controllers Association (NATCA). AIR worked with these FAA sponsors to help identify and disseminate the requirements for participation and to develop a schedule for SME participation in the required exercises. The result of these activities was a detailed research plan for completing the evaluation activities. The next phase of the project will involve conducting focus groups with air traffic control SMEs to assess the alignment of the content of the current form with the content of the job as currently defined in a recently completed ATCS job analysis.

Technical Operations

Safety Culture Transformation in Technical Operations

Summary: The primary purpose of this project at St. Louis University is to measure the status of the safety culture within the Technical Operations segment of the Air Traffic Organization and to develop the appropriate interventions to bridge the largest gaps between existing and desired levels of safety culture.

Description**:** In FY08, emphasis was placed on development and support of a non-punitive error reporting system for Technical Operations as well as evaluation of the safety culture at the end of the research project. Several briefings were held at the demonstration sites to encourage the employees to submit Aviation Safety Action Plan (ASAP) reports. The reports received during the research period were analyzed, and in collaboration with the event review committees, solutions were recommended. The final report was developed. A pre- and post-ASAP comparison of the safety culture showed a slight shift in the safety culture toward the desired direction. This is a desirable shift and evidence that an ASAP program can be effective in improving safety culture. Many of the recommendations resulting from these reports are under implementation, and plans are underway to present the final report and recommendations for national implementation.

Selection Research for Technical Operations Personnel

Summary: Human factors personnel are conducting research on the selection of personnel for the Technical Operations career field. In 2008, they developed a revised automated crediting plan and a prototype guide to use for structured interviews of Technical Operations job candidates.

Description: Human factors personnel are conducting research on the selection of personnel for the Technical Operations career field. In 2008, they finalized and delivered a revised automated crediting plan for the FV-2101 and FV-0856 occupations in ATO

Technical Operations to AJA-55 and AHP-100. They also developed a prototype guide to use for structured interviews for the FV-2101 and FV-0856 occupations. This prototype interview guide was delivered in May 2008 to AJA-55, and has since been implemented by the ATO. Additional research was done identify or develop alternate assessments of non-technical competencies, such as personality tests.

Anthropometric Data Collection of Technical Operations Personnel

Summary: The FAA Human Factors Design Standard (HFDS) provides a wide range of anthropometric data to be used in the design of FAA systems, equipment, and facilities. The HFDS requires that FAA systems and equipment be designed for personnel from the 5th through the 95th percentile levels of the physical characteristics that represent the user population. Because of changes in the workforce over time, human factors researchers are collecting anthropometric measurements directly from members of the Technical Operations workforce. This information will be used to update the HFDS.

Description: Anthropometric data from the FAA Human Factors Design Standard (HFDS) is used in the design of FAA systems, equipment, and facilities. However, the current data is based on measurements taken on Department of Defense (DoD) military personnel over the past 50 years which may not be applicable to the Technical Operations (TO) workforce of today. For example, studies show that there is an increased height and weight of the average American today compared to 20-40 years ago. To that end, it is desirable to collect anthropometric measurements directly from members of the Technical Operations workforce.

In order to collect the desired anthropometric measures, a team is traveling to Technical Operations worksites that have large numbers of personnel. The distribution of the Technical Operations workforce is known in terms of sex, age, and ethnic/racial background. Sites were selected in an attempt to achieve geographical diversity to ensure that the distribution of the sample being measured is representative of the workforce distribution. Data collection has taken place at 25 sites. At these sites, 979 males and 244 females have been measured. The data are being analyzed and the summary statistics prepared. The output will be an update to the Human Factors Design Standard.

Alarms and Alerts in the Technical Operations Environment

Summary: Researchers are producing a stand-alone standards document that provides design criteria and guidance for the presentation of alarm and alerts signals to the Technical Operations environment. Some of the design criteria provided may be applicable to other environments and work forces.

Description**:** An alarm and alert standard summarizing available knowledge regarding the presentation of alarm and alert signals in the Technical Operations environment is being prepared by human factors researchers. This standard builds upon the excellent work conducted by researchers in the Human Factors Research and Engineering Team,

William J. Hughes Technical Center. The standard will provide specific guidance criteria for the colors to be used in the visual alarm and alert signals as well as specific tones to be used in the aural signals.

Human Factors Research and Engineering

Program Description

Program Manager Glen Hewitt directs activities focused on the application and integration of human factors engineering in systems acquisitions related to the definition, procurement, design, development, testing and implementation of diverse systems within the FAA and National Airspace System. Activities are conducted that are associated with building a human factors engineering program within the FAA and its systems engineering community. The program addresses: the application of human factors engineering during mission and requirements analysis and development; investment analysis; product analysis; design, development and testing; source selection preparation and evaluation; and post-deployment data collection and analysis.

The objectives associated with this program are designed to ensure that the incorporation of human factors engineering is explicit, timely, systematic, comprehensive, efficient and effective. Efforts relate to identifying and defining system-specific human factors requirements, assessing human factors risks, providing technical solutions to mitigate risks, advising on policy decisions related to human factors engineering, conducting human factors training, acquiring and supporting human factors tools and technologies, and implementing human factors plans. Technical support to system acquisition programs encompasses areas of study related to human-computer interface, staffing and training, workload, procedures, documentation, communications, and other salient human-system interface issues.

Listed below is a description of FY 2008 Human Factors Research and Engineering activities.

R&D Identification and Mitigation

Summary: The human factors team planned and conducted human factors risk and mitigation review activities across ATO Service Units' systems and applications in order that human factors issues/potential impacts and risks were coordinated and documented. Recommendations and assistance were rendered as appropriate.

Description: Risk and mitigation activities were conducted on acquisitions to document human factors impacts and to provide recommendations. Services included: (1)

supporting the integration of human performance in the NAS Enterprise Architecture by defining a human factors approach, identifying issues and recommendations, and coordinating the approach to be consistent with system engineering activities; (2) identifying and conducting risk reduction activities that directly support the system acquisition programs' ability to meet human factors engineering objectives to deliver high quality products, especially in support of performance-based acquisition requirements determination efforts; (3) supporting ATO-S on Safety Management System and Safety Risk Management initiatives to facilitate integrating human factors engineering in safety applications, especially for human reliability assessments.

R&D Human Factors Engineering Capability Support

Summary: Members of the team facilitated human factors engineering capabilities in the FAA by monitoring, planning, and conducting human factors activities related to policy/guidance, processes, and best practices for FAA system acquisitions.

Description: Human factors engineering capabilities support was provided for FAA systems acquisitions. The team monitors and revises policy and processes related to human factors for the FAA and the Acquisition Management System (AMS). Activities included facilitating the integration of human factors engineering, especially in support of establishing human factors priorities, demonstrating best practices (such as for human factors in Post Implementation Reviews), providing quality control, or standardizing human factors methods, techniques, guidance, and criteria for the AMS and its system acquisitions.

Human Factors Scientific and Technical Support

Summary: Senior scientific and technical advice and assistance on human factors was provided to support the Human Factors Research and Engineering Group and to ensure that the Program Director has the information to successfully manage human factors in FAA acquisition and research programs.

Description: Members of the Human Factors Research and Engineering team provided support to program management through participation at meetings with other FAA lines of business. Human factors personnel also participated in meetings with the Department of Transportation Inspector General, Government Accountability Office, Office of Management and Budget, National Aeronautics and Space Administration, congressional committee staffers, and domestic and international groups with regard to agency human factors issues and accomplishments. A key activity was collaboration with workgroups and organizations to promote human factors engineering initiatives. Team members also supported program managers by providing timely feedback, analysis, coordination, and identification of human factors risk areas that may require senior management's attention.

ATO Model Workplace Standard

Summary: Members of the team demonstrated commitment and support to the agency's Model Equal Employment Opportunity Program by applying equal opportunity principles in order to contribute to a productive, proficient, and hospitable workplace.

Description: The Human Factors Research and Engineering team supported the Model Equal Employment Opportunity Program by: (1) consistently demonstrating and maintaining a positive and professional attitude; (2) promptly initiating resolution of differences with co-workers as soon as situations occur; (3) promoting a work environment that is free of hostile, offensive, or abusive behaviors by not creating or condoning this type of behavior and treating others with dignity and respect in the workplace; (4) exercising courtesy, integrity, and diplomacy in all contacts, both internal and external to the organization; (5) actively demonstrating teamwork through the principles of inclusion, negotiation, effective communications, and collaborative decision-making.