Federal Aviation Administration

Research & Development Annual Review

Accomplishments during FY 2008

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R&D Annual Review: Accomplishments during FY 2008 is available online at www.faa.gov/go/narp

INTRODUCTION

The R&D Annual Review highlights the 2008 research and development accomplishments of the Federal Aviation Administration (FAA), and serves as a compendium to the FAA's recently published National Aviation Research Plan (NARP), 2009 edition. The FAA's Research and Development (R&D) program contributes to the achievement of the 10 R&D goals described in Chapter 2 of the NARP. This publication has been designed to feature accomplishments in accordance to the supported goals: Fast, flexible and efficient; Clean and quite; High quality teams and individuals; Human centered design; Human protection; Safe aerospace vehicles; Separation assurance; Situational awareness; and World leadership.

Additionally, the R&D program supports the FAA's core goals to enhance safety, improve efficiency and increase capacity of the national airspace system or NAS. In that effort, it continues to lay the groundwork for the Next Generation Air Transportation System known as NextGen.

NextGen is a wide-ranging transformation of the entire NAS to meet future demand and support the economic viability of the system while reducing delays, improving safety, and protecting the environment. It is a complex, multilayered, evolutionary process of developing and implementing new technologies and procedures. NextGen is not a single piece of equipment or a program or a system that will instantaneously transform the NAS. It is an evolutionary process, and existing systems must be sustained in the transition. NextGen builds on legacy systems to increase capability in today's airspace system, adds new performance-based procedures and routes, and ultimately delivers programs that will transform the NAS

How the FAA will achieve that NextGen transformation is detailed in some of the R&D accomplishments found in this issue.

Fast, Flexible and Efficient: Today, capacity for closely spaced parallel runway operations is dramatically reduced in poor visibility conditions. The R&D program is working on capabilities that allow for continued use of runways during low visibility by providing precise path assignments that permit safe separation between aircraft assigned on parallel paths, restoring capacity and reducing delays throughout the system.

Clean and Quiet: Increased efficiency with NextGen operations will lead to reduced fuel consumption resulting in lower carbon emissions. The agency's R&D effort is researching engine and airframe design and alternative fuels that will produce the changes needed to reduce aviation's environmental impact.

These accomplishments begin to tell the NextGen story and provide a glimpse into the future of our nation's world class aviation system and the immense benefits it will continue to provide to the American people.

FAST, FLEXIBLE, AND EFFICIENT

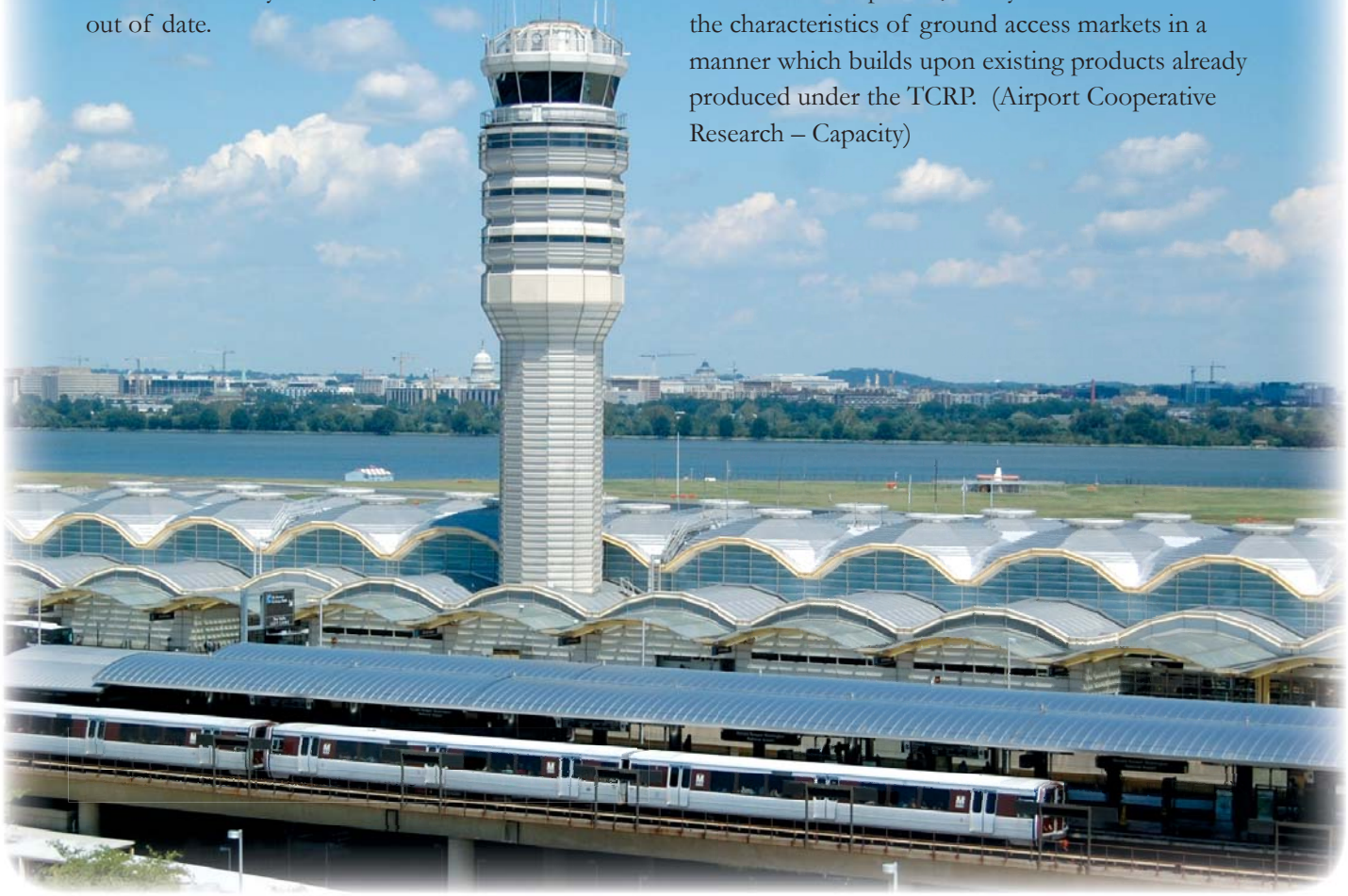
A system that safely
and quickly moves anyone
and anything, anywhere,
anytime on schedules
that meet customer needs

Ground Access to Major Airports by Public Transportation

Airports around the United States, and around the world, are dealing with the challenge of improvement to the ground access systems. In the past five years several major American airports have invested hundreds of millions of dollars in new capital facilities to connect their facilities with the rest of the region's public transportation systems.

To deal with this issue, the Transit Cooperative Research Program (TCRP) six years ago undertook two major studies of the issue of airport ground access, published as TCRP Report 62 and TCRP Report 83. These two studies presented accurate, up-to-date descriptions of major airport access projects and strategies around the world. With the creation of the Airport Cooperative Research Program, there is an opportunity to revise, update, and build upon a substantial body of work, which is now somewhat out of date.

The objectives of this project are to: 1) improve the documentation of all airport ground access projects, with an emphasis on those which have occurred since the publication of TCRP Report 62 in 2000; 2) improve the documentation of changes in airport access strategies since the publication of both reports with a review of recent developments in such areas as downtown check- in, automation of the check in process, and integration with existing regional rail infrastructure; 3) provide airport managers with user-friendly, concise, and accurate documentation concerning trends in the area of airport ground access; and 4) support and facilitate the dissemination of the latest information relative to airport managers through media such as printed reports, and PowerPoint presentations to relevant professional organizations. The proposed research will create new updated, timely documentation of the characteristics of ground access markets in a manner which builds upon existing products already produced under the TCRP. (Airport Cooperative Research – Capacity)

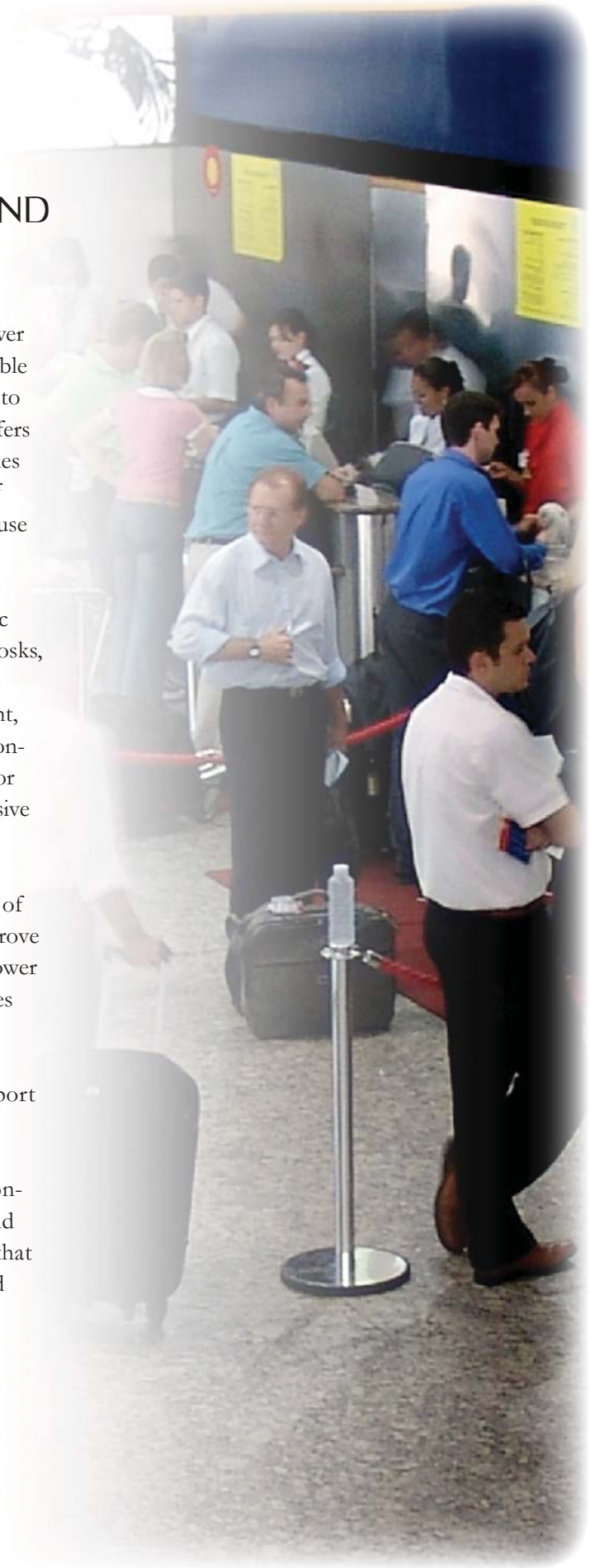


Common Use Facilities and Equipment at Airports

As airports work with airlines to increase efficiency, lower costs, and improve customer service, there is considerable interest and activity in transitioning from exclusive-use to common-use facilities. In many cases, common-use refers to information technology applications that allow airlines to manage their passenger operations at any number of gates. This project broadens the concept of common use to include facilities and practices.

Facilities that can be shared to serve the traveling public can include, but are not limited to, lobbies, ticketing, kiosks, baggage systems, hold rooms, gates, loading bridges, aprons, preconditioned air and power, remain over night, rental car facilities, and transportation centers. Common-use practices include, but are not limited to, providing or expanding common-use facilities and disbanding exclusive use facilities, gate utilization monitoring, lease and use agreement modifications, and competition plans. The focus of this project is to compile and list of the types of common use facilities, methods, and practices that improve the success of sharing facilities to increase efficiency, lower costs, and improve customer service as well as the issues that hinder common use.

The intended audience of this guidance includes airport managers considering transition to common use of some facilities. The purpose of this research is to survey airports on their current and planned common-use facilities in order to document the advantages and disadvantages of common-use systems, procedures that require modification to implement common-use, and the participant's actual experience to date. (Airport Cooperative Research – Capacity)



Controller Aids for Aircraft on Terminal Air Navigation Routes

Researchers from the Center for Advanced Aviation System Development (CAASD) completed development of two prototype aids that have the potential to help controllers manage traffic in the area navigation (RNAV) environment by providing additional information on their radar situation displays. The first aid projects an image that conveys the relative position for converging traffic that will help controllers early in coordinating merging RNAV arrivals. The second aid is an automated visual alert to controllers that provides early warning of aircraft deviations from assigned RNAV routing and altitude constraints.

The first controller aid, termed the Relative Position Indicator (RPI), projects an image (symbol) on the radar situation display that conveys the relative position for converging traffic. This allows controllers to manage merging traffic as if it were in-trail and to do so farther from the expected merge point. Early availability of relative position information enables the controller to avoid vectoring and issue subtle control inputs, such as speed control, utilizing the extra distance to allow the input to take effect. Approach controllers could use RPI to manage merges within their airspace as well as to increase awareness of traffic being worked by other controllers that will affect a downstream merge. Traffic Management Coordinators could use RPI to inform runway assignment decisions and to better manage airport configuration changes.

The second controller aid is automation to quickly alert controllers of aircraft deviation from assigned RNAV routing. The prototype monitors each aircraft's position relative to an acceptable position region defined around the RNAV centerline. If the aircraft exits this region, an alert is displayed in the data block for the aircraft on the controller's radar situation display. Compliance to altitude constraints along the RNAV route are also monitored, with the automation issuing an appropriate alert if the aircraft deviates vertically from the RNAV route profile. By helping controllers detect deviations earlier, controllers can quickly contact the pilot and issue a corrective clearance, reducing the probability of conflicts with or disruptions to surrounding traffic. (CAASD)

Equivalent Visual Operations for the National Air Space

The integrity of air traffic operations in the National Airspace System (NAS) depends on the ability to provide visual separation between airborne aircraft, either by controllers in air traffic control (ATC) towers or by aircraft flight crews. Key resources such as airport arrival and departure capacity depend to a great degree on this ability to conduct visual operations. Operations in the NAS degrade enormously when meteorological conditions do not permit visual operations. Technologies such as Automatic Dependent Surveillance Broadcast (ADS-B), RNAV and required navigation performance (RNP), and advances in wake turbulence technology may enable a recovery of much of this lost capacity if these concepts are harnessed in a creative and integrated way. CAASD researchers formulated over a dozen promising concepts for equivalent visual operations for the NAS and achieved very promising results for one of them. The concepts range from increasing the arrival and departure capacity of single and parallel runways in low visibility, to increasing airspace capacity with more closely spaced routes.

CAASD researchers developed and evaluated an advanced version of a concept for improving arrival capacity of single runways in low visibility conditions called IMC CAVS-S (Cockpit Displays of Traffic Information (CDTI) Assisted Visual Separation for single runway approaches in Instrument Meteorological Conditions). During visual operations to single runways, pilots provide their own separation and spacing on final approach to runways, resulting in significantly more efficient operations to the airport. Although a concept had been developed in the past for enabling pilots to provide CDTI assisted visual separation, concern for potential wake encounters had precluded applying that concept in low visual meteorological conditions (VMC) and IMC. For this advanced concept CAASD developed prototype cockpit tools to allow flight crews to assess and avoid the potential for wake encounters in lower weather conditions. The evaluation, utilizing pilots in CAASD's cockpit simulator, showed that flight crews could use the proposed CAVS tools comfortably below visual approach minima, down to ceilings and visibility of 1,000 feet and 3 nautical miles respectively. The evaluation also indicated that runway arrival capacity may be improved significantly for airports like Los Angeles International when its weather conditions deteriorate below visual approach minima. This first evaluation demonstrated that there is good potential for developing a generalized capability with ADS-B-based CDTI that could significantly back-fill the capacity lost in the NAS when controllers and flight crews cannot use visual separations. (CAASD)

NextGen Wake Separation Standards, Processes, and Decision Support Tools

In January 2008, a feasibility cost/benefit analysis was completed on a potential concept for an ATC wake turbulence mitigation decision support tool that would allow more landings to an airport's closely spaced parallel runways when weather conditions at the airport require use of instrument approach procedures. Work continues to develop alternative concepts that might yield more benefit to airport operations.

In July 2008, a joint U.S. and European working group completed an initial analysis of potential static wake separation standard sets that could support the increasing number of aircraft designs that are being introduced into the world's air transportation system. The next step is to evaluation further more promising (in terms of capacity enhancing and safety) sets to include human in the loop simulations of their use. (Wake Turbulence)

Integrated Departure Route Planning

In daily operations when air traffic demand on the NAS or on specific resources – sectors, routes, and fixes – is predicted to exceed capacity, a variety of traffic management initiatives (TMIs), such as reroutes, miles-in-trail flow restrictions, and ground delay programs are generated by traffic flow management to ensure an expeditious flow of aircraft. This is especially crucial when system capacity is reduced by severe weather. In current operations, with limited automation support, traffic managers must mentally integrate the traffic, weather, and airspace resource information and project that information into the future. This process is difficult and time consuming, often leading to inaccurate information. As a result, TMIs are often too large scale, too inflexible, and/or not effectively used to respond to dynamically changing weather conditions. To maximize traffic throughput while maintaining safety, it is desirable to minimize the impact of TMIs on operations and to implement only those initiatives necessary to maintain system integrity.

CAASD researchers jointly with the Massachusetts Institute of Technology (MIT) Lincoln Laboratory developed a concept and prototype for integrated departure management decision support in convective weather that, for the first time, integrates traffic, weather, and airspace resource information into a common test bed and laboratory prototype, the Integrated Departure Route Planner (IDRP). IDRP combines predictions of weather impact along departure routes, predictions of congestion at departure fixes and in nearby en route airspace, and an automated reroute identification algorithm into a single decision support tool that could help traffic managers implement reroutes for departures blocked by weather or traffic constraints. IDRP first identifies departure flights whose flight plans cannot be executed due to weather or volume constraints, and then searches a set of alternatives acceptable to TFM and airline operations to find a feasible reroute. IDRP also provides automated support and information to help decision makers evaluate and implement different solutions. It takes into account all significant data such as filed flight plans and acceptable alternatives, surface departure queues, predicted convective weather and traffic congestion impacts to routes in the terminal area and nearby en route airspace, and forecast uncertainty.

Initial experiments indicate that an integrated departure route planning capability could reduce the time needed to coordinate, implement, and revise TMIs and departure management plans as weather and traffic situations change dynamically. This could improve significantly system performance. It could also reduce the workload associated with determining 4-D (space & time) intersections of departure traffic flows, translating those impacts to departure times, and determining a suitable alternative departure route for aircraft. (CAASD)

Airport Traffic Control Tower Simulation Infrastructure Development

Although ATC simulators exist, the FAA did not own an ATC tower (ATCT) research simulator. This lack of infrastructure severely limited the FAA's ability to evaluate future concepts such as those proposed in NextGen. The FAA human factors researchers defined the requirements for a full-scale ATCT simulator, including a set of simulation pilot commands. They used these requirements to create a state-of-the-art ATCT research simulator. This simulator will be used for the systematic evaluation of NextGen ATCT concepts.

Numerous 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.

Over the past two years, researchers established basic aircraft surface movement models and defined the requirements for a full-scale ATCT simulator, including a set of simulation pilot commands. A research team added to existing surface movement capabilities developed in the previous years by refining aircraft behavior, bolstering simulation pilot commands, and implementing data collection and reduction capabilities. They expanded the realism by creating new aircraft models and liveries and by creating the foundation to support a 270-degree out-the-window view.

The result of this project is an FAA owned and developed ATCT simulation software platform including underlying software and nine large-screen displays that can support a 270-degree out-the-window view. The ATCT simulator provides a high fidelity representation of airport operations including aircraft models, simulation pilot interface, and commands. The ATCT simulator also includes data collection and reduction applications, and adds a basic Information Display System display to the existing suite of ATCT displays. This ATCT simulation infrastructure will allow the FAA to research concepts such as the Staffed NextGen Tower, digital data communications, and integrated ATCT information displays. (ATC/Technical Operations Human Factors)

Air Traffic Control Changes in Applying Wake Separations

In September 2008, the FAA approved a national ATC order permitting controllers at specific airports, having closely spaced parallel runways spaced less than 2500 feet apart, to use a new wake mitigation separation procedure. The procedure will allow six to ten more landings on those runways when weather conditions otherwise would have required the use of a procedure that is equivalent to using just a single runway for landing. The procedure is similar to a procedure used in inclement weather for parallel runways separated more than 2500 feet.

The development and approval of this order is based on the wake turbulence data collection and analyses, human in the loop simulations, procedure development, and safety analyses done by the Wake Turbulence Research Team (Volpe National Transportation Systems Center, MITRE CAASD, wake and weather sensor developers, and FAA).

The order is slated for initial implementation at five Next Generation Air Transportation System (NextGen)/Operational Evolution Partnership (OEP) airports (Lambert – St. Louis International Airport – currently authorized via waiver developed in 2007, Cleveland Hopkins Airport, Philadelphia International Airport, Seattle-Tacoma International Airport, and Boston Logan International Airport). (Wake Turbulence)

Wake Turbulence Mitigation for Departures

FAA expanded the models it uses to determine the operational benefits of the Wake Turbulence Mitigation for Departures (WTMD) decision support tool at ten candidate NextGen/OEP airports to enable greater departure capacity for closely-spaced parallel runways (parallel runways spaced less than 2500 feet apart). Algorithm validation tools were developed to evaluate the reliability of the WTMD cross-wind predictions. Data-based wake encounter models, developed to evaluate the safety risk associated with the change in operational ATC wake mitigation procedures at Lambert St. Louis International Airport, were enhanced for use in evaluating the safety risk of using the procedure at other airports with similar runway configurations. Additionally, the model was modified to evaluate the safety risk of WTMD-based ATC departure procedures.

The WTMD decision support tool development was a joint research endeavor with the National Aeronautics and Space Administration (NASA) developing the concept and building the feasibility prototype, MITRE CAASD providing human in the loop simulations of the tool's use and benefit data, Volpe National Transportation Systems Center collecting and analyzing thousands of wake tracks of departing aircraft, the MIT Lincoln Laboratory developing the tool's internal cross wind forecast algorithm, and the FAA – both headquarters and field Air Traffic Organization personnel – detailing and evaluating the use of the proposed decision support tool. (Wake Turbulence)

Caption: NASA R&D microphone array used for aircraft wake data collection at Denver International Airport

Clean and quiet

A reduction of significant aerospace environmental impacts in absolute terms

National Parks and Air Tour Noise Research

In June 2008, the FAA Western Pacific Region, the FAA Office of Environment and Energy, and Volpe National Transportation System Center signed a memorandum of understanding to pursue several research efforts to advance noise impact analyses for the National Parks Air Tour Management Plan (ATMP). The program aims to develop a scientifically defensible approach for determining significant noise impacts from aviation-related projects in naturally quiet areas. The objectives of the program are to: 1) enhance noise modeling fidelity to capture noise propagation effects critical for naturally quiet areas; 2) establish noise exposure-response relationships for naturally quiet areas; 3) identify noise exposure thresholds to establish significant noise impact; and 4) establish analytical procedures specific to determining significant noise impact in naturally quiet areas. The program will support implementation of the National Park Air Tour Management Act of 2000, which requires the FAA, in cooperation with the National Park Service, to develop an ATMP for parks and tribal lands where air tour operations occur or are proposed.

Research is being pursued by four noise projects. The first focuses on the complex noise modeling issues associated with parks, modeling method enhancements are sought to better capture effects of terrain, ground and meteorology on noise propagation and effects of overlapping flights in high altitude. This project will apply a parabolic equation model, deemed by consulted experts, to be the most promising approach to simulating the effects of terrain, ground and weather on noise propagation. For the second project, a source data collection is underway to acquire noise data for several air tour aircraft currently not available in the INM aircraft database, as well as to support of helicopter noise modeling and data validation in collaboration with manufacturers. Noise measurement testing has been scheduled this year for the Bell 407 helicopter, the Schweizer 300C helicopter, and the Piper PA-42 Cheyenne fixed-wing propeller aircraft. The third project is developing guidance on characterizing ambient noise for diverse National Park settings that will lead to a comprehensive guidance document for noise impact analyses in naturally quiet areas such as National Parks. Lastly, the fourth project is to map out the next phase of research to establish noise exposure-response relationships applicable to National Parks based on a workshop feedback from October 2008 in which leading experts participated. (Environment and Energy)

Airport Particulate Matter Emissions Research

Domestic airports and the aviation-industry partners that rely on these airports must assure compliance with current particulate matter (PM) controls, as called for in existing environmental requirements and state implementation plans and in the National Ambient Air Quality Standards (NAAQS) as enforced by the U.S. Environmental Protection Agency (EPA). In addition, it is anticipated that future standards will be more stringent. In February 2003, the U.S. General Accounting Office (GAO) released a report (GAO-03-252) titled Aviation and the Environment: Strategic Framework Needed to Address Challenges Posed by Aircraft Emissions. In this report, the Secretary of Transportation directed the FAA, in consultation with the EPA and NASA, to develop a strategic framework for addressing emissions from aviation-related PM sources. In developing the framework, known as the PM Roadmap, FAA was directed to coordinate with the airline industry, aircraft and engine manufacturers, airports, and the states with airports that were in areas of non-attainment of air quality standards.

A critical foundation to ensure the success of the framework rests on identification of critical gaps in existing research on PM emissions at airports. A comprehensive review of existing research findings and an evaluation of current research efforts are, therefore, essential. The roadmap also will define a prerequisite for airport inventories in the future in which databases will be augmented with practical assessments of PM emission source contributions in an airport environment. Within the aeronautical and environmental communities, gaps in the understanding of quantitative aggregate and local contributions of PM emissions at airport sites exist. Specifically, the relative contributions of various sources of PM emissions, such as the ambient environment, aircraft gas turbine engine combustion processes, diesel combustion processes, and non-combustion releases of PM emissions from other airport equipment and sources, is not known.

The aviation community needs comprehensive information on PM emissions data at airport sites. This information will lead to improved emissions and PM databases that will provide a benchmark for future measurements, modeling efforts, and estimation of emissions. More importantly, this information is needed to respond to pending compliance issues, prioritize future investment by the government and private sector, and ensure a sustainable air transportation system. An understanding of the amount, types, and sources of PM emissions at airports will enable the aviation industry to respond better to more restrictive environmental compliance issues in the future. (Airport Cooperative Research – Environment)

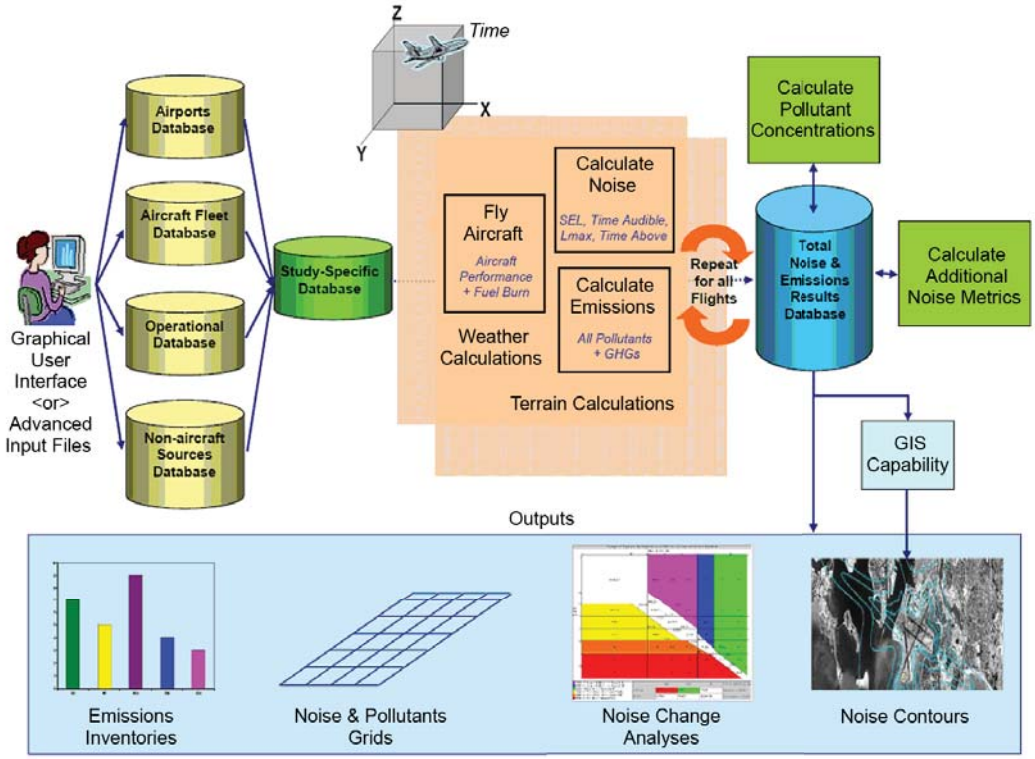
Aviation Environmental Design Tool

The accuracy of estimating fuel burn, noise, and emissions during low speed portions of flight has been greatly enhanced in the Aviation Environmental Design Tool (AEDT) as a result of an agreement between Boeing and FAA to exchange aircraft performance tools. This improved modeling capability was used in the analysis of continuous decent arrivals (CDA) and tailored arrivals (TAs) at several major U.S. airports, and benchmarked against historical dive-n-drive procedures to understand the benefits of reduced fuel burn, noise, and emissions. AEDT was used to model CDA and TA implementations as part of the Atlantic Interoperability Initiative to Reduced Emissions (AIRE) program and NextGen operational scenarios.

AEDT was used in support of the International Civil Aviation Organization (ICAO) Committee on Aviation Environmental Protection (CAEP) to begin the policy analyses for setting new nitrogen oxide (NOx) emissions standards for new certified

engines. Researchers integrated common modules and databases as well as implemented many concepts of the overall AEDT architecture to develop worldwide estimates of fuel burn, emissions, and noise. The modeling effort, also known as the "NOx Stringency" analysis, included modeling the global fleet at reduced engine NOx levels ranging from zero percent (no stringency) to 20 percent lower standards than what exists today for the implementation years of 2012 and 2016. These NOx stringency scenarios are then modeled for future forecasted years of 2016, 2026, and 2036 to investigate the overall NOx emission reduction trends as a result of these policy options. Even though ICAO's focus is on NOx emission standards, AEDT also produced the interdependent impacts of noise and fuel burn, unlike any other aviation environmental tool in use today to support ICAO's policy decisions. Demonstration to inform policymakers is the integration of AEDT results with the economic analysis capability in the Aviation environmental Portfolio Management Tool.

Development efforts included further integration of AEDT with databases that support the Joint Planning and Development Office's vision for NextGen. This work involved updating AEDT modules and databases to link directly with the NASA Airspace Conflict Evaluation Simulator (ACES) tool. Full integration of ACES and AEDT will allow for streamlined and consistent analysis of aviation environmental issues during the design of NextGen. In addition, AEDT was selected as the aviation environmental consequence model by the winning teams of NASA research announcements for the design of advanced aircraft concepts deployed in NextGen operational scenarios. In this capacity, AEDT will be integrated with other airspace and airport planning tools such as FAA's airspace and airport simulation tool (SIMMOD) and the FAA's Terminal Area Route Generation, Evaluation, and Traffic Simulation (TARGETS). (Environment and Energy)



Caption: Schematic of Aviation Environmental Design Tool

Alternative Fuels for Aviation

Interest in alternative fuels for commercial aviation has continued to grow. While the price of oil has declined since a high of $147 per barrel during the summer of 2008, its volatility and expected increase continues to drive the development of alternative fuels. Environmental concerns and energy supply security also continue to be critical drivers, and alternative jet fuels can significantly contribute to addressing these concerns.

The FAA and U.S. industry-sponsored Commercial Aviation Alternative Fuels Initiative (CAAFI) has become the principal forum to coordinate an international effort to develop, certify, and deploy alternative aviation fuels to supplement petroleum-based jet fuel. CAAFI's participants include a cross-section of airlines, manufacturers, airports, fuel producers, researchers, federal agencies, and international players. This innovative group of stakeholders continues to implement a CAAFI roadmap to explore the use of alternative fuels for commercial aviation. The combined efforts of CAAFI stakeholders are rapidly advancing the potential move to alternative aviation fuels.

CAAFI stakeholders lead critical activities to develop new fuel specification and certification processes via ASTM International. If certification activities are successful, alternative synthetic paraffinic kerosene (SPK) jet fuel produced from coal, natural gas, and biomass via the Fischer-Tropsch (F-T) process may be approved by June of 2009. This generic fuel approval will enable the use of SPK fuel from many different producers. Approval of similar fuel approvals for bio-jet fuels from hydro-treated renewable oils and other advanced processes are expected within a few of years.

In September 2008, the CAAFI Business and Economics Team convened a two-day summit of 130 representatives of the commercial aviation and alternative fuels development and production communities. The meeting strengthened relationships among the airlines and potential alternative fuel suppliers, which will significantly advance commercial negotiations critical to deployment. It also refined CAAFI's roadmaps that address technical and approval hurdles for alternative jet fuel implementation and presented federal government investment opportunities for alternative fuel producers. The CAAFI business meeting demonstrates that the commercial aviation sector has the desire to lead a movement toward eco-friendly alternative fuels.

In coordination with CAAFI, investigators from the Partnership for AiR Transportation Noise and Emissions Reduction (PARTNER) have completed a landmark study of alternative fuels that addresses the technical feasibility, identifies the drivers for adoption, identifies the types of infrastructure to support transition, and determines what measures might promote alternative fuels. The study concluded that alternative fuels now exist that could reduce greenhouse gas emissions and improve local

air quality, but at present the ability to produce these fuels is limited and the costs of production are high. Some of these potential environmental benefits are possible from alternative fuels that are lower in sulfur and aromatics than conventional petroleum fuels. In the short term, air quality benefits could be attained through the removal of sulfur from conventional petroleum fuels to yield lower particulate matter emissions.

The study also began to investigate the environmental life-cycle of various fuel options to understand the full impact of their production and distribution. Alternative aviation fuels from biomass were found to offer substantial life-cycle greenhouse gas emissions reductions relative to conventional jet fuels; however, land use changes could potentially offset these gains. For alternative aviation fuels, attaining carbon neutral growth will be a challenge without carbon capture and sequestration, investments in new plants to process alternative fuels, investments in new technologies for higher efficiencies from renewable resources, and minimizing the possible impacts on land and water resources that may occur. Further work will focus on refining the life-cycle analysis data to include these land use impacts. Some of these important considerations include possible displacement of food crops, carbon capture and sequestration, striking a balance between aviation and other transportation modes, and incorporating these results into models that will highlight the local, national, and global changes that may occur in their use.

In December 2007, in collaboration with industry and the U.S. Department of Defense, PARTNER investigators conducted a study to quantify changes in particulate matter and hazardous air pollutant emissions on a high production commercial aircraft engine using standard jet fuel and various blends of alternative fuels. The study also aimed to demonstrate the viability of alternative "drop-in" fuels, such as bio-fuel and F-T fuel, for normal use in commercial aviation. During the emissions tests, the engine was cycled through a matrix of reproducible engine operating conditions. Emissions and steady-state engine data were collected at each condition using a sampling probe that was positioned near the engine exhaust nozzle. The test cycle was repeated for each fuel-blend and baseline fuel. The measurements indicated that, especially for the 100 percent F-T fuel, particulate matter emissions number and mass was diminished at all powers relative to baseline fuel. Some significant differences in hydrocarbon emissions speciation were also observed for the 100 percent F-T fuel. Differences were less pronounced for mixes of alternative fuels with standard jet fuel.

In July 2008, the Secretary of Transportation announced the award of an FAA grant to the X Prize Foundation (www.xprize.org) to develop a prize contest that will spur innovation in alternative aviation fuels. Prize contests have a storied history in aviation, inspiring achievements and innovations that have advanced the human frontier -- the Orteig prize, for example, inspired Charles Lindbergh to cross the Atlantic. So, it is fitting that this tradition be continued to advance a new frontier for aviation – environmentally sound, renewable alternative fuels. Over the next 14 months, the X Prize Foundation will use experts from the government, industry, and academia to develop the aviation renewable fuels prize package and implementation plan. The prize package and implementation plan will be used by industry and the government to identify prize sponsors and initiate the prize competition. In addition to CAAFI and PARTNER's activities, the Alternative Aviation Fuels X Prize should also help to stimulate private investment in technology, focus public attention, and develop the supply of renewable fuel in quantities to serve the commercial aviation sector. (Environment and Energy)

Hazardous Air Pollutant Research

Increasingly, airports and the FAA are asked by various agencies and communities surrounding airports to analyze the health impacts of aircraft and other airport-related sources of air toxics, also known as hazardous air pollutants (HAPs), in the National Environmental Policy Act (NEPA) and state-level documents. Unlike criteria air pollutants, however, information on the emission, transformation, and transport of aircraft and other airport-related HAPs and their health impacts is extremely rudimentary. Without an understanding of aircraft HAPs emissions, airports are unable to quantify the contribution of aircraft and non-aircraft emissions. As airport activity continues to grow, understanding the relationship between HAPs and their impact will become increasingly important.

Several studies have been conducted to understand this relationship better, including the airport development program Environmental Impact Statements for Philadelphia International Airport and Chicago O'Hare International Airport, and a HAPs-related human health risk assessment at Oakland International Airport. Additionally, as a follow-up effort to its 2003 state of science report, the FAA is currently assembling a HAPs Emissions Inventory Guidance document to establish a nationally consistent methodology for quantifying HAPs from aircraft engines. The methodology will be able to incorporate future data on HAPs emissions as they become available. However, as emphasized in the Critical Issues of Aviation and the Environment 2005 report issued by the Transportation Research Board Committee on Environmental Impacts of Aviation (AV030), these studies are only a starting point to understand the impacts of HAPs.

This project produced a comprehensive prioritized agenda of research needs associated with aircraft and other airport-related sources of HAPs. The agenda provides a framework that allows the aviation community to perform future research in a coordinated manner. The agenda identifies the types of HAPs being emitted, their sources, detection and measurement, and possible health and other environmental impacts. It has a schedule, explains how the findings would be used by airport operators and the general public, and provides supporting evidence for the reasoning behind the agenda priorities. (Airport Cooperative Research – Environment)

Energy Use at U.S. Airports

The enormous size and complexity of airport facilities are fertile ground for finding common solutions to intricate problems such as the environmental impact and operating expenses from unnecessary energy use. Many airports are under pressure to reduce air emissions from ground transportation and fossil fuels. As a result, they are constantly seeking ways to grow sustainably within their local communities. To complicate matters, the rapidly escalating energy prices continue to be a major part of airport operating expense. Energy is most often the second largest operating expense at airports, exceeded only by personnel. Airport facility managers must strive to reduce these costs to help lower the bottom line for their airline tenants.

The good news is that energy is a very controllable operating expense if they use more efficient lighting, heating, cooling, people movers, ground transportation, and other airline operations. By prudent, energy efficiency investments and optimizing operations, airports can reduce operating costs from 10 percent to 30 percent annually. For example, an energy assessment and "Continuous Commissioning (CC)®" of the new central rental car facility at Dallas/Fort Worth International Airport in 2005 has resulted in a metered 20 percent reduction in energy use. The practical solutions to improve airport efficiency are documented and can be replicated through the dissemination of "best practices".

This project completed a guidebook that provides airport managers, operators, and their operations and maintenance contractors with information to improve energy use at our nation's airports. By developing and encouraging the widespread use of energy management "best practices," airport managers can significantly reduce operating costs and reduce the impacts on environmental compliance while providing a very visible example for communities and others to follow. (Airport Cooperative Research – Environment)

International Noise Technology Goals

Future efforts to mitigate aircraft noise are dependent on quieter technologies and operations. The FAA is working with the International Coordinating Council of Aerospace Industries (ICCAIA) under the auspices of ICAO/CAEP to establish aircraft noise technology and air traffic operational goals in the mid-term (10 years) and the long-term (20 years).

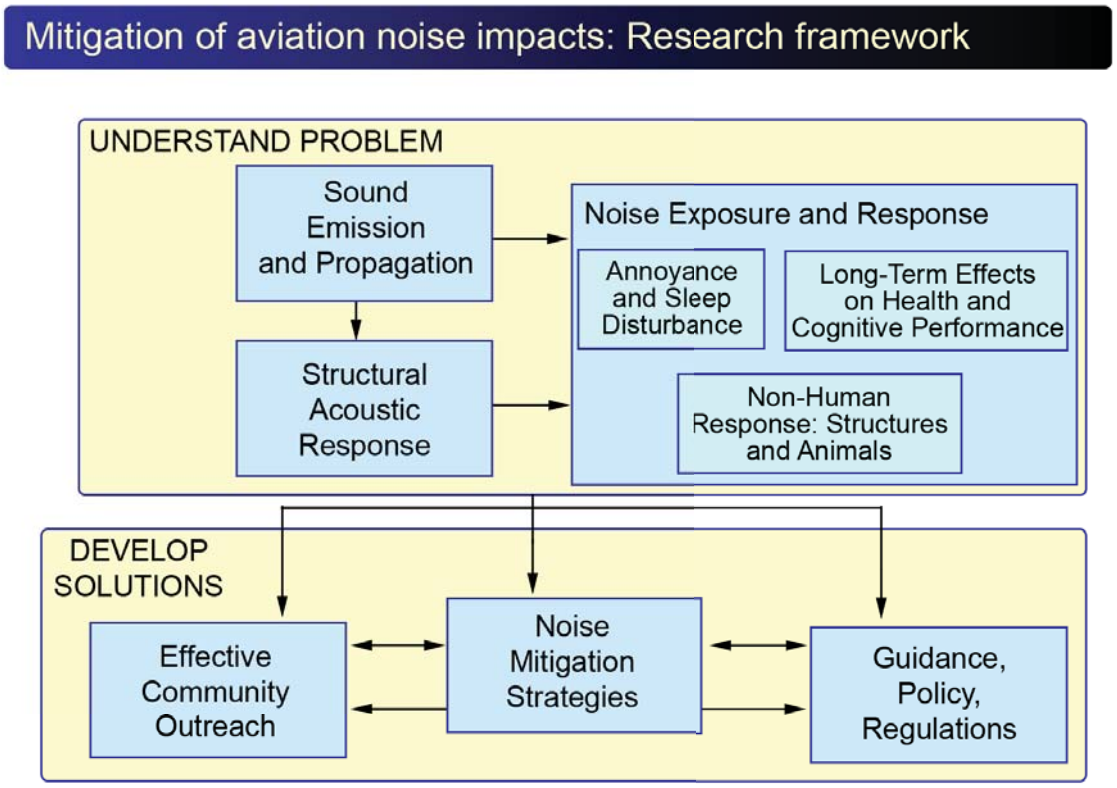
In September 2008, FAA co-sponsored a workshop and independent expert review in Seattle, Washington, dedicated to aircraft noise reduction technology that was a significant step toward this goal. Through a detailed and comprehensive review of noise reduction technologies currently being developed worldwide, an international panel comprised of experts from Canada, France, Japan, Russia, United Kingdom, and the U.S., will make recommendations for a consensus set of mid-term and long-term noise technology goals. The goal setting process offers multiple benefits. It provides an independent perspective that may be used to help guide technology investment decisions, including those of the CLEEN program, provide benchmarks against which to chart technological progress, help us envision and plan for aviation's future environmental performance (globally as well as domestically for NextGen), and inform and complement the noise standard-setting process. (Environment and Energy)

Aircraft Emissions Inventories

In collaboration with the EPA, the FAA has completed a new speciated hydrocarbon profile for aircraft equipped with turbofan, turbojet, and turboprop engines. The new speciated hydrocarbon profile identifies 77 individual organic compounds, including 17 known hazardous air pollutants. It is based on the multiple measurement data sets generated from three Aircraft Particle Emission eXperiments (APEX) field campaigns, which are co-sponsored by NASA, FAA, California Air Resources Board (CARB), and the EPA. This is the first time that aircraft hydrocarbon emissions have been characterized based on repeatable measurements spanning multiple commercial aircraft engines from every major manufacturer.

The FAA and EPA have jointly developed a recommended best practice document that provides the technical support information for the new speciated hydrocarbon profile as well as how to conduct aircraft emission inventories for individual hydrocarbon species. The EPA has included this new profile into their SPECIATE database for use in national emission inventories. Likewise, the FAA has incorporated it into its Emissions and Dispersion Model System version 5.1 for improved accuracy. The profile is also being used to develop guidance for quantifying speciated gas phase hydrocarbon emissions to provide consistency in aircraft emission inventories assembled for disclosure purposes under NEPA. (Environment and Energy)

New Noise Research Program



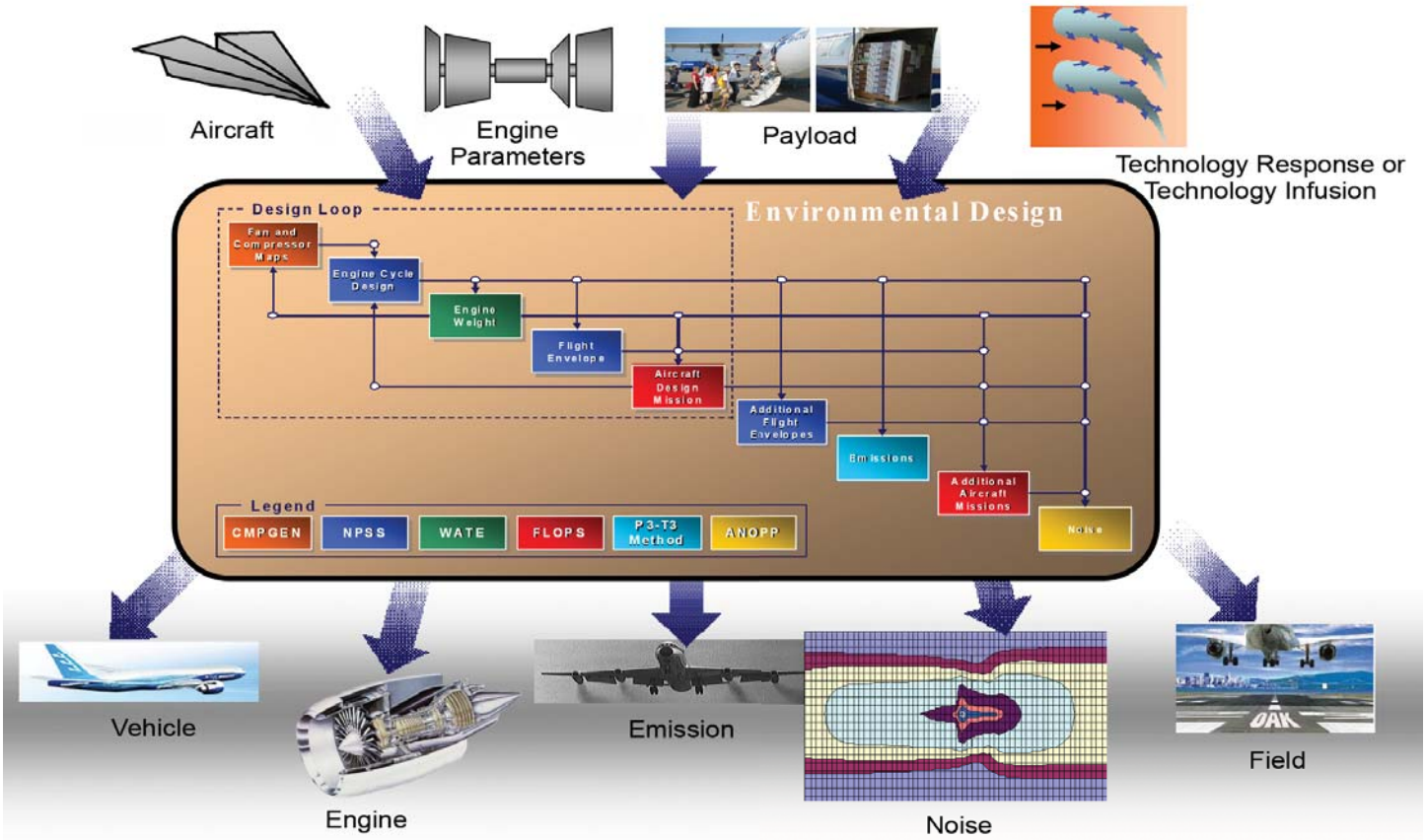
Despite our favorable historical record in having substantially reduced the number of people exposed to significant noise, airport noise restrictions and public opposition to airport and airspace projects continue to rise. Therefore, a robust noise research program is needed to realize our NextGen vision of providing a level of environmental protection that allows sustained aviation growth. A strategic research framework has thus been developed aimed at: improving public health and welfare near-term and in future growth scenarios; informing NextGen decisions with more accurate, comprehensive, and integrated analyses; and garnering greater public acceptance of future airport and airspace capacity projects, as well as the operation of future unconventional aircraft. To accomplish these goals, the research program must improve our understanding and quantification of aviation's noise impacts as well as develop more cost-effective/cost-beneficial mitigation solutions.

The first half of the FAA strategy focuses on research and development to improve our understanding of the airport community noise problem – following the path of the noise from its point of emission through its propagation and transmission to the community, and ending with the community's response to the noise. The second half of the research strategy focuses on solutions to alleviate the problem, which includes advancing each of the four elements of a balanced approach towards community noise mitigation, comprising of noise reduction at the source (i.e., the aircraft), land use compatibility planning and management, noise abatement operational procedures, and aircraft operational restrictions. The new research strategy will be presented to potential research partners and stakeholders who will jointly develop an execution strategy. (Environment and Energy)

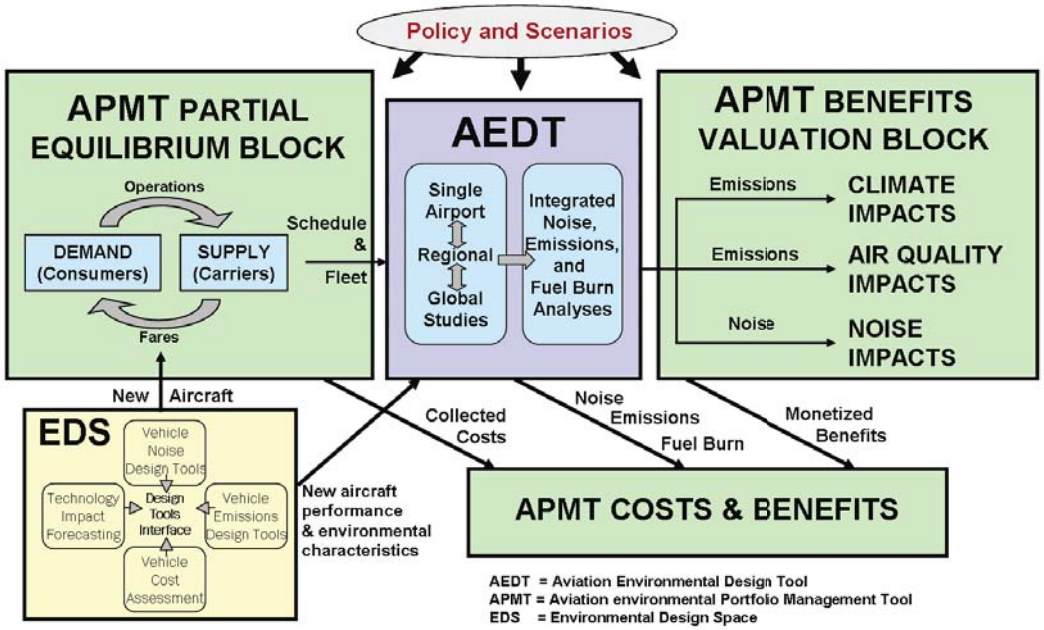
Scenarios and the Environmental Design Space Tool

The Environmental Design Space (EDS) tool estimates source noise, exhaust emissions, performance, and economic parameters for aircraft designs under different technological, policy, and market scenarios. The model quantifies engine/airplane system design trades in a manner that is technically feasible in terms of performance, noise, and emissions. This capability allows for assessments of interdependencies between aviation-related noise and emissions effects. Design trade spaces will be developed for each of the ICAO passenger classes, ranging from 50 passengers to 650 passengers. Each vehicle passenger class will have both a current technology trade space and a future technology trade space. The current technology trade space allows for changes to engine cycle parameters that are bounded by the limits of current certified technology. The future technology trade space would produce potential future vehicles defined within trade spaces estimated assuming potential future technology with a mid- to long-term development focus.

The EDS development team completed validation of the current technology 300- passenger twin-aisle and 150-passenger single-aisle aircraft trade spaces. The 50-passenger aircraft trade space is currently being reviewed by the EDS Independent Review Group. In addition, the FAA refocused EDS development to future technology trade spaces to enable technology applications in support of NextGen analysis. As a result, the EDS fundamental architecture was significantly enhanced to streamline the structure of execution and file conventions. The new EDS Version 3.0 enables the development team to reduce human error and enhance version control of inputs and outputs generated. Further enhancements have been made to improve compressor and turbine map generation, to include technology factors and vary the aircraft within the trade space generation, to develop a fan stratification model to enable proper fan technology modeling, and to incorporate low speed aerodynamic surrogates. (Environment and Energy)



Aviation Environmental Portfolio Management Tool



Historically, aviation environmental modeling tools generated either noise or emissions outputs, after which the costs to implement a policy were considered against a single environmental performance indicator (e.g., NOx emitted). Subsequent advances on common databases and inputs have highlighted the need to consider noise, local air quality, fuel burn, and greenhouse gas emissions interdependencies and to monetize costs and benefits. The FAA is developing a comprehensive suite of software tools that will allow for thorough assessment of the environmental effects of aviation. The main goal of the effort is to develop a new capability to assess the interdependencies between aviation-related noise and emissions effects, and provide comprehensive impact, and cost and benefit analyses of aviation environmental policy options. The impact and economic analysis function of this suite of software tools has been given the rubric Aviation environmental Portfolio Management Tool (APMT).

APMT takes aviation demand and policy scenarios as inputs, and simulates the behavior of aviation producers and consumers to evaluate policy costs. Detailed operational modeling of the air transportation system within the Aviation Environmental Design Tool provides estimates of the emissions inventories and noise exposure. A benefits valuation module within APMT then is used to estimate the health and welfare impacts of aviation noise, local air quality, and climate effects, using a variety of metrics. These metrics include monetary estimates of the value of changes in environmental quality.

A substantial effort to engage the scientific and stakeholder community in review of APMT methods and outputs culminated in acceptance for APMT use in upcoming ICAO/CAEP/8 cost effectiveness analyses. The benefits valuation aspects of APMT were used to support the Joint Planning and Development Office submission to the Office of Management and Budget (OMB). A study of the high-density airports case was the first practical domestic use of APMT to monetize aviation environmental impacts. Technical advances in APMT methodology were documented in a graduate thesis on "World Housing Valuation" and a journal article on the "Impact of Reduced Vertical Separation Minimum on Aircraft-related Fuel Burn and Emissions."

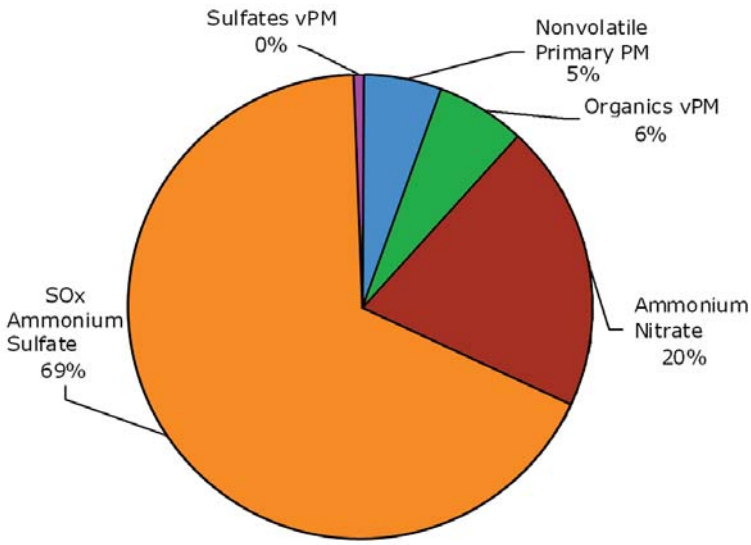
2008 also saw the initiation of a collaborative effort with the University of Cambridge, Aviation Integrated Modeling (AIM) group. Under the auspices of the PARTNER Center of Excellence, the APMT development team held two workshops with the AIM group to develop research initiatives that will benefit both modeling teams. Tangible collaboration and resource sharing has become a part of both programs with researchers spending time at both institutions. This work has shown that impacts of cruise emissions on air quality are much larger than originally thought and must be accounted for in health impact analyses. (Environment and Energy)

Desulfurization of Aviation Fuel to Mitigate Environmental Impacts

Aircraft exhaust emissions contribute to both air quality and climate impacts which could be the limiting factor for aviation growth. Therefore, to allow sustain aviation growth, one of the environmental goals of the NextGen is to limit or reduce emissions impacts on the environment.

Generally, there are tradeoffs in emissions and associated environmental impacts when there is an attempt to reduce a particular type of 'direct' emission. For example, high temperature combustion is desirable for maximum thermodynamic efficiency and lowest fuel efficiency (i.e., low CO2 emissions). However, NOx emissions could be reduced by controlling combustor temperatures and decreasing the residence time during high temperature operations. Emissions of CO2 are known to contribute positively to climate impacts whereas NOx emissions potentially contribute to both air quality through formation of secondary air pollutants, such as particulate matter and ozone, and climate impacts through changes in atmospheric distributions of ozone and methane. However, there are no significant tradeoffs with other emissions in reducing gaseous emissions of sulfur dioxide (SO2).

Sulfur is present in the jet fuel as a part of crude oil processing. It is considered to be useful in engine lubrication. During fuel combustion, sulfur in the fuel undergoes oxidation process which leads to direct emissions of gaseous SO2. While interacting with the background atmosphere and with other emissions from aircraft exhaust, gaseous emissions of SO2 ultimately lead to the formation of secondary sulfate aerosols which contribute to ambient air quality. A number of FAA funded research studies have conclusively demonstrated the contribution of sulfate aerosols to the overall change in particulate matter at various spatial scales brought by aircraft emissions. Therefore, there is an obvious air quality benefit of desulfurization of aircraft fuel. Sulfate aerosols, in general, are known for negative climate impacts (i.e. cooling) and also participate in heterogeneous chemistry that could affect ozone distribution and also aid the formation and persistence of contrails and induced cirrus clouds – all of which potentially contribute to climate change. However, there is no clear indication about the net climate impacts of change in direct emissions of SO2.



Caption: Preliminary analysis of distribution of health cost (~$767M) attributable to changes in particulate matter in the United States due to present aircraft emissions within LTO cycle. Note that about 69% of the total health cost is due to sulfate aerosols.

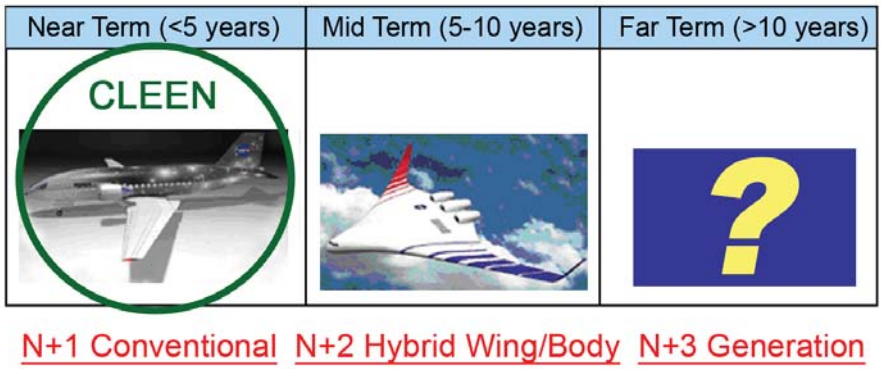
Preliminary cost-benefit analysis of aircraft fuel desulfurization using FAA's APMT has shown results of sufficient merit that warrants more detailed and more complete study. It has conclusively demonstrated air quality benefits of using ultra low sulfur aircraft fuel. This initial study only focused on aircraft emissions within the landing and takeoff (LTO) cycle. The FAA has just funded a project to PARTNER to examine the environmental benefits of ultra low sulfur aircraft fuel. This project will focus on two scenarios of fuel sulfur content (600 parts per million and 15 parts per million worldwide) and will use a number of air quality and chemistry-climate models for simulations and analysis. This study will also examine the relative contributions from aircraft emissions within LTO cycle and at cruise altitude to surface air quality. Results from air quality and climate impact analyses will be used in FAA's APMT model for cost-benefit analyses. This project is being led by MIT with participation from Stanford University, Cambridge University and University of Houston as well as consulting support from Harvard University. MIT will work very closely with the Coordinating Research Council to develop the cost associated with desulfurization of jet fuel as well as infrastructure needed for implementation of ultra low sulfur aircraft fuel. Results from this study are expected to be available by the end of summer next year. (Environment and Energy)

Continuous Lower Energy, Emissions, and Noise Program

Continuous Lower Energy, Emissions and Noise (CLEEN) technologies program is designed to target maturation of promising technologies to reduce aircraft environmental impact and energy usage. Award of contracts under CLEEN is dependent on approval of FY 2009 funding.

A market research conference for the proposed CLEEN program was held in May 2008. At the conference, the FAA presented information on CLEEN and obtained feedback from potential bidders on the program scope. In parallel with the conference, FAA conducted a market survey for the CLEEN program. In the survey, the FAA requested information from interested parties on capabilities, expected programmatic approach, teaming partners, and potential technology development efforts. The FAA is using information obtained from these activities in developing the request for proposals for the CLEEN procurement.

Under the proposed CLEEN program, FAA and industry will cost share, on a 1:1 minimum basis, development of CLEEN technologies for civil subsonic jet airplanes to help achieve the NextGen goals to increase airspace system capacity by reducing significant aircraft noise and emissions. The CLEEN program is also focused on increasing the fuel efficiency and advancing alternative fuels for aviation use. The focus of this effort is to: 1) mature previously conceived noise, emissions and fuel burn reduction technologies to enable industry to expedite introduction of these technologies into current and future aircraft and engines, and 2) assess the benefits and advance the development and introduction of alternative "drop in" fuels for aviation, with particular focus on renewable options, including blends. (Environment and Energy)



Impact of Airport Pavement Deicing Products on Aircraft and Airfield Infrastructure

Field reports increasingly suggest that the use of pavement deicing products (PDPs), including alkali acetate and alkali formate products (such as sodium- and potassium- acetate and formate based products), on aprons, runways, and taxiways may result in substantial damage to various aircraft and airfield infrastructure. One example is the impact on the carbon brakes of modern transport aircraft. Damage may result in reduced brake life and introduces the possibility of brake failure during high-speed aborted takeoff with the concomitant risk of fire from hydraulic fluid released during such an event. Other examples include reports of cadmium corrosion, aluminum corrosion, corrosion in landing gear joints, electrical wire bundle degradation, corrosion of runway lighting fixtures, and damage to airfield infrastructure associated with the use of PDPs.

This research assembled information obtained from other related research and updates it to include quantities and types of PDPs used over the years. The report contains a matrix identifying specific PDPs used and their respective volumes at each surveyed airport. It examines results from a literature search and assembles documentation of damage reported from the use of PDPs at airports, including reports from the FAA, aircraft brake manufacturers, airframe manufacturers, airlines, airports, and PDP manufacturers, along with any information on outcomes from reported damage.

The report examines how airports deice their airfield pavements, what chemicals are commonly used, the amounts applied, and the existence and validity of any evidence of associated corrosion or degradation of aircraft and airfield infrastructure. These results will help federal authorities institute appropriate regulatory requirements and help airport operators and airlines perform more efficiently during winter operations. (Airport Cooperative Research – Environment)

Aviation Climate Change Research Initiative

Aviation is an integral part of the global economy and transportation system. Projections indicate that the demand for aviation could grow by a factor of 2-3 over the next two decades. Although rising and volatile fuel prices are slowing demand at present, expansion of aviation is likely to continue and, as in the past, could outpace economic growth. In the absence of mitigating actions, increased aviation operations will likely result in higher related emissions and associated environmental impacts including those on climate.

At present, aircraft emissions are a very minor contributor to overall emissions. However, the relative magnitude of aircraft emissions is expected to increase due to projected growth in its own sector as well as decreasing emissions from non-aviation sources. If not effectively managed and mitigated in a timely manner, future environmental impacts will be the principal constraint on the capacity and flexibility of NextGen that is being designed and implemented to meet the projected aviation growth. One of the NextGen environmental goals is to limit or reduce climate impacts of aviation.

Actions needed to mitigate environmental impacts will likely include technological innovation (e.g., engines, aircraft and fuels), operational and market-measures, and regulatory interventions. No single action will likely achieve all targeted goals. Mitigation options generally come with tradeoffs and interdependencies that must be properly understood before optimally balanced cost-beneficial options can be designed and implemented. On the climate front, development of the mitigation

options requires better scientific understanding and characterization of the non-CO2 climate impacts due to aircraft gaseous and particle emissions as well as the formation of contrails and induced cirrus clouds. There is also a need for a suitable metric that can interrelate these non-CO2 climate impacts and that can measure aviation CO2 emissions alone. These are the areas of the most scientific uncertainties, which must be understood so that the well-informed options for decision-making can be developed.

To meet the NextGen environmental goals, the FAA has developed the Aviation Climate Change Research Initiative (ACCRI) with participation from NASA, the National Oceanic and Atmospheric Administration, and EPA. These federal agencies are also key contributors to the U.S. Climate Change Science Program. The main objective of ACCRI is to identify and address key scientific gaps and uncertainties regarding climate impacts while providing timely scientific input to inform optimum mitigation actions and policies. The ACCRI approach is to support aviation-specific climate change research that is policy relevant and solution focused and to coordinate as well as link its research needs and activities with related national and international climate change research efforts.

ACCRI completed two key initial steps as part of its 4-step structured and sequential approach to: 1) review of science and analysis capability, and 2) identify gaps and develop recommendations for the priority research. Under the first step, ACCRI funded eight national and international groups of research experts to develop eight whitepapers. These were on various aspects of aviation climate change to review the state of science, analysis capability, scientific uncertainties as well as to identify gaps and develop research priority based on the maximum return of the investment on near (up to 18 months), mid (up to 36 months) and long (beyond 36 months) time horizons. Under the second step, ACCRI convened an international science meeting that was attended by about 100 experts from academia, research institutions, and industry. A report on The Way Forward with collective recommendations on the research priority was released. The science meeting concluded that ACCRI needs to be a priority driven research program with responsibility to deliver realistic outcomes scheduled to match decision-making. The eight whitepapers and the ACCRI report can be accessed via the internet at http://www.faa.gov/about/office_org/headquarters_offices/aep/aviation_climate.

The recommendations for the way forward are already being used to communicate with stakeholders as well as national and international research programs to seek their support and to develop strategy and planning for near-term and mid- to long- term research activities and practical applications. All are being designed to better inform decision-making in a timely manner. (Environment and Energy)

International Aviation Interoperability to Reduce Environment Impacts over the Atlantic and Pacific Oceans

Since the launch of the Atlantic Interoperability Initiative to Reduce Emissions Partnership with Europe, FAA has worked closely to: 1) hasten development of operational procedures to reduce aviation's environmental footprint for all phases of flight; 2) accelerate world-wide interoperability of environmentally-friendly procedures and standards; 3) capitalize on existing technology and best practices; and 4) provide a systematic approach to ensure appropriate mitigation actions with short, medium and long-term results.

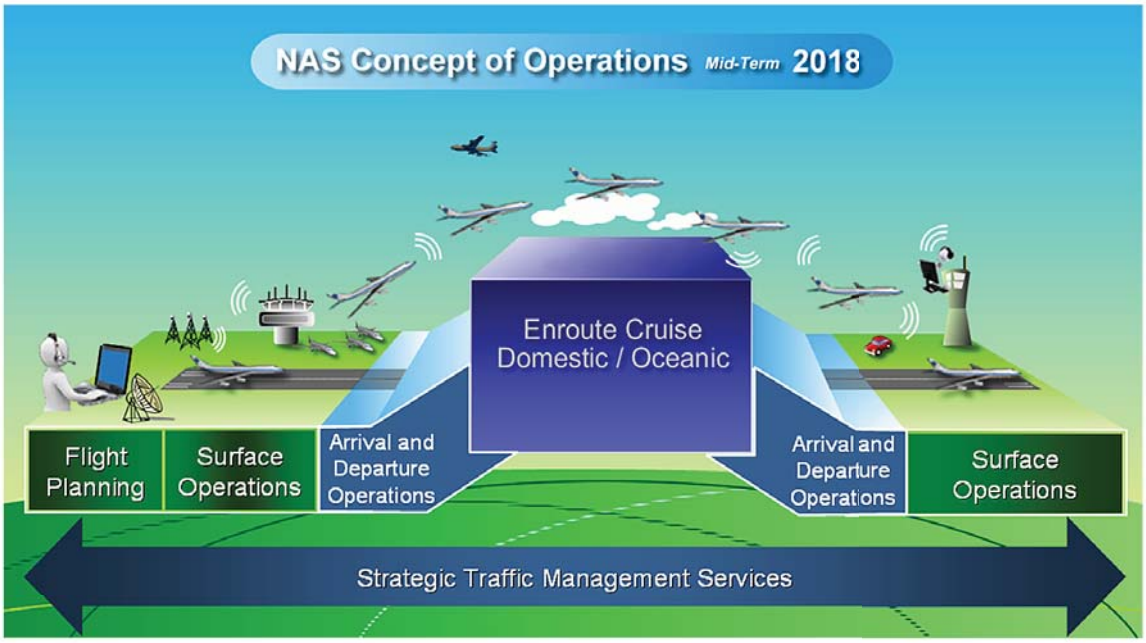
Simply put, the FAA and European authorities continue to enhance air traffic management interoperability, improve energy efficiency, reduce engine emissions, and lower aircraft noise. In fact,

FAA has moved swiftly to establish partnerships and execute several system demonstrations of oceanic, surface, and terminal/en route system and/or procedures. In May 2008, demonstrations of oceanic procedure enhancements with Air Europa proved that rerouting and altitude changes offered near-term fuel consumption and emission reduction benefits within the current standards of operating procedures. Similarly, two continuous descent arrival demonstrations were performed by FAA in joint collaboration with American Airlines at Miami International Airport and Delta Airlines at Atlanta International Airport. Significant fuel saving, reductions in noise and engine emission were achieved. The environmental benefits ranged from savings of 38-50 gallons of jet fuel per flight that equates to a reduction of carbon dioxide (CO2) of approximately 500 kg per flight.

On February 18, 2008, a multi-lateral partnership known as the Asia and South Pacific Initiative to Reduce Emissions (ASPIRE) was created in Singapore. The first air navigation service providers to sign the ASPIRE joint statement were Airservices Australia, Airways New Zealand, and the FAA. Similar to AIRE, the initial partners under ASPIRE are committed to work closely with airlines and other stakeholders in the region in order to:

- accelerate the development and implementation of operational procedures to reduce the environmental footprint for all phases of flight on an operation by operation basis, from gate to gate;
- facilitate world-wide interoperability of environmentally friendly procedures and standards;
- capitalize on existing technology and best practices;
- develop shared performance metrics to measure improvements in the environmental performance of the air transport system;
- provide a systematic approach to ensure appropriate mitigation actions with short, medium and long-term results; and
- communicate and publicize ASPIRE environmental initiatives, goals, progress and performance to the global aviation community, the press and the general public.

The first flight to participate under ASPIRE was designated "Aspire 1" when departing 19:30, Friday 12, September 2008 from Auckland, New Zealand, to San Francisco. This flight brings together Air New Zealand, the FAA, and Airways New Zealand to demonstrate the advances being made to reduce aviation emissions in the Asia/South Pacific region, through a demonstration of the most advanced air navigation services and airline fuel optimization initiatives in current operation. (Environment and Energy)



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Cockpit Task Demands

In conducting research on airliner cockpit demands for the FAA, NASA researchers observed pilot training classes and 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 that was 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. Jump seat observations, however, 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 were vulnerable to forgetting to perform intended actions, such as when: 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 why even the most expert of pilots was vulnerable to commit errors. The book provides detailed guidance on countermeasures that individuals and organizations can take to reduce vulnerability to error in these common situations. It also 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 any area of skilled operator performance. This research provides measures to improve the design of pilot training and of operating procedures, which addresses the FAA objective of improving aviation safety. (Flightdeck/Maintenance/Systems Integration Human Factors)

Air Traffic Control Safety Risk Assessment Analysis

Researchers from the Civil Aerospace Medical Institute (CAMI) 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 analyses to be conducted that take into account the amount of time 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 ten minute time intervals was computed for six en route centers having the largest number of OEs during 2006. The probability of an OE occurring within any given 10 minute interval ranged from .002 percent (at the 90 min. interval) to .006 percent (at > 120 min. interval), resulting in an overall cumulative probability of .05 percent.

This means that, within the NAS, on average, there is a .05 percent chance that an OE will occur during a position change sometime within a given two hour period. This kind of information is useful for constructing Bayesian networks to determine the risks associated with controlling air traffic and, as such, would be useful for monitoring the effectiveness of automation designed to mitigate those risks. However, it should be pointed out that not all risks associated with ATC can be empirically derived. If data do not exist, such as in the case of the probability that a controller will make decision A, B, or C, then expert judgments must be made. These judgments then can be used in conjunction with empirical data to create a more comprehensive ATC safety risk assessment, which would then feed into an ATC Safety Management System. (ATC/Technical Operations Human Factors)

Air Traffic Control Specialist Biographical Data and Interview Selection Procedures

CAMI developed a structured interview process 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 the Air Traffic Organization and operational use began in FY 2007. Follow-up will occur in FY 2009 to determine that the process is being used properly.

Researchers developed a biographical inventory called the CAMI Life Experiences Questionnaire (CLEQ). It was intended to be used to refer ATC specialist applicants to second-stage aptitude testing using the Air Traffic Selection and Training (AT-SAT) selection battery. While the original CLEQ is not being used for that purpose, a shortened, empirically-keyed, response-option scored version is currently being developed and will be completed in 2009. The CLEQ v2.0 may eventually be added to the AT-SAT testing process.

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 about the hiring process that were identified by the new controllers were summarized and reported as an interim product. (ATC/ Technical Operations Human Factors)

Air Traffic Control Selection Instruments: Assessment of Cognitive Aptitude

CAMI tested 72 FAA Academy ATC classes (1,069 students). The purposes of the test were to: 1) obtain biographical information about incoming ATC students; 2) obtain information relevant to the longitudinal validation of the Air Traffic Selection and Training (AT-SAT) test battery; and 3) 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 help FAA determine if the job of the ANSP will be sufficiently different from today's ATC Specialist 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 predict correctly PV outcomes for 73.5 percent of the trainees. Thus, the use of AT-SAT as a selection instrument has additional support. (ATC/Technical Operations Human Factors)

Controller Displays for Severe Weather Avoidance

Adverse weather conditions affect flight operations overall but are especially hazardous to general aviation aircraft. The primary weather hazards are icing, convective activity (i.e., thunderstorms), and reductions in ceiling/visibility. Some two-thirds of all general aviation accidents that occur in IMC are fatal. As a result, air traffic controllers are being asked to take a more pronounced role in ensuring that pilots, particularly general aviation pilots, remain clear from hazardous weather conditions. Tactical controllers, however, have only limited information available to provide this service.

Because of this information shortcoming in en route and Terminal Radar Approach Control operations, researchers at the William J. Hughes Technical Center developed concepts for how to display relevant weather information on air traffic controller workstations. Additionally, they developed a working prototype of an automated support tool called AIRWOLF that tracks general aviation 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. These weather tools can give air traffic controllers the information they need to help general aviation pilots avoid weather hazards. Used together, they could help to reduce weather-related general aviation accidents and provide information that would enhance cockpit decision-making. (ATC/Technical Operations Human Factors)

Color Vision Tests for Air Traffic Control Specialist Applicants

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 FY 2007, and was validated for operational use the following year. ATCOV validation consisted of two studies. The first tested 81 color vision deficient and 152 color-normal subjects. This study provided information about the test's validity, reliability, and standardization. The validation empirically indicated that, with selected cut-off scores, ATCOV exhibits high specificity and sensitivity. Approximately 7 percent of color vision deficient applicants are expected to pass the test, as they will perform as well as 95 percent of the normal population. ATCOV was demonstrated to be highly reliable and can be self-administrated or instructor-administrated with minor training of proctors. (ATC/ Technical Operations Human Factors)

Advanced Systems for Air Traffic Workforce Training

The FAA has a critical need for innovative approaches that will strengthen air traffic controller training to reduce the time and resources required to provide ongoing instruction of current controllers as well as a strong training program for the thousands of controllers that will be hired over the next decade. CAASD researchers made significant progress in helping the FAA leverage advanced training technologies to meet the challenge in both the en route and terminal domains.

Utilizing the CAASD developed high-fidelity en route ATC training prototype (known as the enroute Trainer), the FAA conducted training sessions with Developmental Controllers at the FAA's Indianapolis Air Route Traffic Control Center to evaluate new training technologies and capabilities and their associated benefits, and to define baseline requirements for integrating these new en route training capabilities across the NAS. These capabilities included a fully automated simulation pilot capability that can be used in place of human simulation pilots for many scenarios. Based on the evaluations, functional requirements and specifications for an automated simulation pilot capability, including aviation-specific speech recognition algorithms, were documented and tech-transferred for use in ERAM. Other capabilities that were evaluated included the use of skill enhancement scenarios and recorded live traffic that provided a more solid foundation for key skills needed for on-the-job training; the use of "pause and playback" during student scenario operation that enabled the instructors to stop scenarios and point out key emerging events and discuss different control options; and the use of student performance measures to help the instructor assess achievement of key competencies.

CAASD has also developed a terminal trainer prototype that is designed to demonstrate the use and benefits of interactive training technology and intelligent training system design for use in the terminal ATC training domain. Phase 1 of the prototype is a stand-alone capability that leads students through the Miami TRACON training curriculum using state of the art voice synthesis, game technology, simulation, and interactive design. The Phase 1 prototype was reviewed with Miami TRACON representatives in September 2008, and received approval for a field evaluation by students and instructors at the Miami TRACON. The field evaluation will be used to validate these capabilities through use in training actual terminal ATC students. The benefits of these capabilities will be assessed in terms of improved training quality and efficiency. (CAASD)

Methods to Assess Applicant Temperament and Emotional Stability

Based on empirical research, CAMI replaced the 16 Personality Factor (16 PF) test, a psychological screening test for ATC Specialist applicants, with the Minnesota Multiphasic Personality Inventory-2 (MMPI-2). Such screening is mandated by FAA Order 3930.3A. The MMPI-2 was found to be a more sensitive indicator of potential psychopathology than was the 16PF. Now candidates who are flagged with psychological testing will be offered secondary screening. The assessment process has also been moved from a paper-and-pencil task requiring two hours to administer and a week to score, to an on-line experience requiring only 35 minutes to administer with near-instantaneous scoring. Using the MMPI-2 and the improved secondary screening process, the FAA is now more likely to identify applicants with medically disqualifying conditions as early in the application process as possible.

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 informing 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 with several groups of pseudo-applicants to be sure it worked and ensure the security of the data transmission; and 4) 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 the ATO 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. (ATC/Technical Operations Human Factors)

Future En Route Workstation II Simulation

There are estimates that the demand for air transportation may double or even triple over the next twenty years. To achieve this, air navigation service provider efficiency and effectiveness will have to double or triple. This project is one in a series of Future En Route Workstation (FEWS) simulations aimed at demonstrating that these increases are feasible through the use of automation and standardization of operations, procedures, and information.

The FEWS II simulation compared controller performance, workload, and capacity to safely control increasing amounts of air traffic using the three workstations. First, the FAA has added automation to the current en route ATC workstation – the Display System Replacement (DSR) – that controllers use through existing or auxiliary displays. The En Route Automation Modernization (ERAM) workstation under development provides some integration of these capabilities. FEWS is based on ERAM but has additional integration of the capabilities as well as automation to minimize the amount of "housekeeping" tasks that controllers must perform. These modifications are guided by human factors design principles that strive to: limit or eliminate the number of disparate windows and lists or makes them optional, provide access to information through the fewest number of steps possible, present information

to the user when and where needed, prevent time sharing of information, maintain consistency across display windows, connect information across the display that relates to the same object, place related information in close proximity, and use consistent layout formats to support user learning and automated human behaviors. In addition, the simulation compared the workstations with and without data communications and with staffing of either one or two controllers per sector.

Twelve Certified Professional Controllers from Level 11 and 12 Air Route Traffic Control Centers participated in the simulation. Generic airspace was used that participants from different facilities could learn quickly. In the primary experimental design, each participant completed 12 test scenarios that lasted up to 60 minutes, but the controllers could stop earlier if the traffic level exceeded their capacity (approximately 50 aircraft would be in the sector at 50 minutes). The simulation was conducted at the FAA William J. Hughes Technical Center Research, Development, and Human Factors Laboratory. The Distributed Environment for Simulation, Rapid Engineering, and Experimentation was used to emulate features and functions of the alternative controller workstations; the Target Generation Facility to transmit aircraft information from simulation pilot workstations to the controller display; and the Center-Terminal Radar Approach Control (TRACON) Automation System to transmit and receive additional system data. System and controller performance data was recorded and analyzed, including the number of aircraft handled, time and distance in the sector, controller workload, situation awareness, and ratings of system features. Controller eye movement data and data entries was measured and analyzed for each test condition.

The FEWS II simulation resulted in fewer data entries and showed a reduction in controller workload when data communications was available in a two-person sector but not under the one-person sector conditions. The results indicate that the FEWS II workstation with a two-person sector and data communications available also had a significantly lower number of controller deviations. Regression analyses showed that, at the same workload level, controllers could handle more aircraft when they worked as a team using data communications instead of voice communications only. When controllers worked the one-person sector with the FEWS II workstation, they were not able to handle more aircraft with the addition of data communications. The results of the simulation were published in a 2008 technical report Future En Route Workstation Study (FEWS II): Part I – Automation Integration Research (DOT/FAA/TC-08/14, II). (ATC/ Technical Operations Human Factors)

Flight Simulator Fidelity Requirements Research

Much of initial and recurrent airline pilot training is done 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 experience of applicants, and the increasing complexity of the traffic mix and the pilot task with the transition to NextGen. 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 contribute to this transfer.

A systematic examination of full fight simulator (FFS) requirements 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 addressed 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 the Volpe National Transportation System Center. This research is being coordinated with ICAO working groups. Research is also focused on evaluation of the Full Flight Trainer, 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. (Flightdeck/Maintenance/System Integration Human Factors)

Mental Model Assessments for Training Design and Assessment

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 may be evidenced by the consistent findings of gaps and misunderstandings in pilots' knowledge of the automation they interact with. So far, research has yielded several important results: a software tool to computerize the process of knowledge solicitation and assessment using card sorts and concept maps, guidelines for the effective use of the tools, and identification of the suitability of simplified assessment methods while maintaining the reliability and validity of the method.

In an effort to encourage the use of knowledge structure assessment methods that can assess and diagnose misunderstandings or gaps, researchers at the University of Central Florida developed a study protocol that aims to support development of guidelines that will standardize the use of knowledge structure evaluation methods. Specifically, human factors researchers are focusing 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.

The study, which began in 2008, addresses the need for knowledge structure assessment guidelines by investigating factors that may influence the validity and reliability of concept map assessments and the role check pilots play in the assessment process. Factors such as experiences with the assessment process and the information being assessed are 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. (Flightdeck/Maintenance/System Integration Human Factors)

Research on the Human Factors of Conveying Safety-Critical Information

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 Voluntary Safety Program Office, researchers at the University of Central Florida (UCF) are actively involved with research on systems that convey safety critical information, including Notices to Airmen (NOTAMs) 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.A systematic human factors analysis of the current WBAT system was conducted in co-operation with researchers from UCF and from George Mason University. UCF researchers also established a partnership with an airline to obtain realistic data samples from its voluntary programs for data mining and analysis studies. By having access to the results from these systematic examinations, FAA will be better able to understand the quality, frequency, and type of information transmitted through these systems. Further, by applying human factors guidelines and understanding the psychometric principles of these programs, the FAA intends to make recommendations on current and future information sharing programs. (Flightdeck/ Maintenance/ System Integration Human Factors)

Understanding Human Performance in Aviation

This research supports the re-design of the NOTAM system. NOTAMs provide safety- and time-critical information to pilots, dispatchers, and other participants in the NAS. In the past, this system relied mostly on a format appropriate for limited bandwidth teletype machines. With the introduction of modern telecommunications tools and means, such as the internet and the World-Wide Web, the format of NOTAMs, which had many human factors shortcomings, could be improved considerably. Graphical depictions of NOTAMs, as well as natural language text, are formats that are now technically feasible. The FAA plans to overhaul the NOTAM system with the objective of developing a fully digitized NOTAM system.

The American Institutes for Research (AIR) disseminated reports on 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 through 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, researchers from AIR and the University of Central Florida provided AIM with human factors related guidance regarding the digital NOTAM data entry system. 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. (Flightdeck/Maintenance/System Integration Human Factors)

Weather-Related Training and Testing of General Aviation Pilots

Weather-related accidents, particularly accidents due to visual flight rules (VFR) flight into IMC, are associated with the highest fatality rate within general aviation (GA). Specifically, the fatality rate of VFR into IMC accidents is approximately 80 percent compared to roughly 19 percent 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 train and evaluate the skills of GA pilots empirically 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 need to develop Advanced Simulator Weather Simulations. Accomplishments include:

- A systematic review and critique of the weather-related material disseminated by the FAA and weather-related test questions contained in the FAA private pilot written exam. Researchers also examined knowledge deficiencies of pilots on weather-related exam questions and the relationship between performance on the written exam and performance on the private pilot oral exam. Results were published as a technical report located at http://www.humanfactors.illinois.edu/Reports&PapersPDFs/TechReport/08-01.pdf
- The research team completed a study involving a flight simulation protocol which required VFR-only pilots to interpret pre-flight weather information for a specific route of flight that had been prepared using real-time weather information. Pilots were tasked to make pre-flight decisions based on this information, and they were then asked to fly the routes in the flight simulator. Data analysis is currently in progress.

(Flightdeck/Maintenance/Systems Integration Human Factors, Weather Program)

HUMAN-CENTERED DESIGN

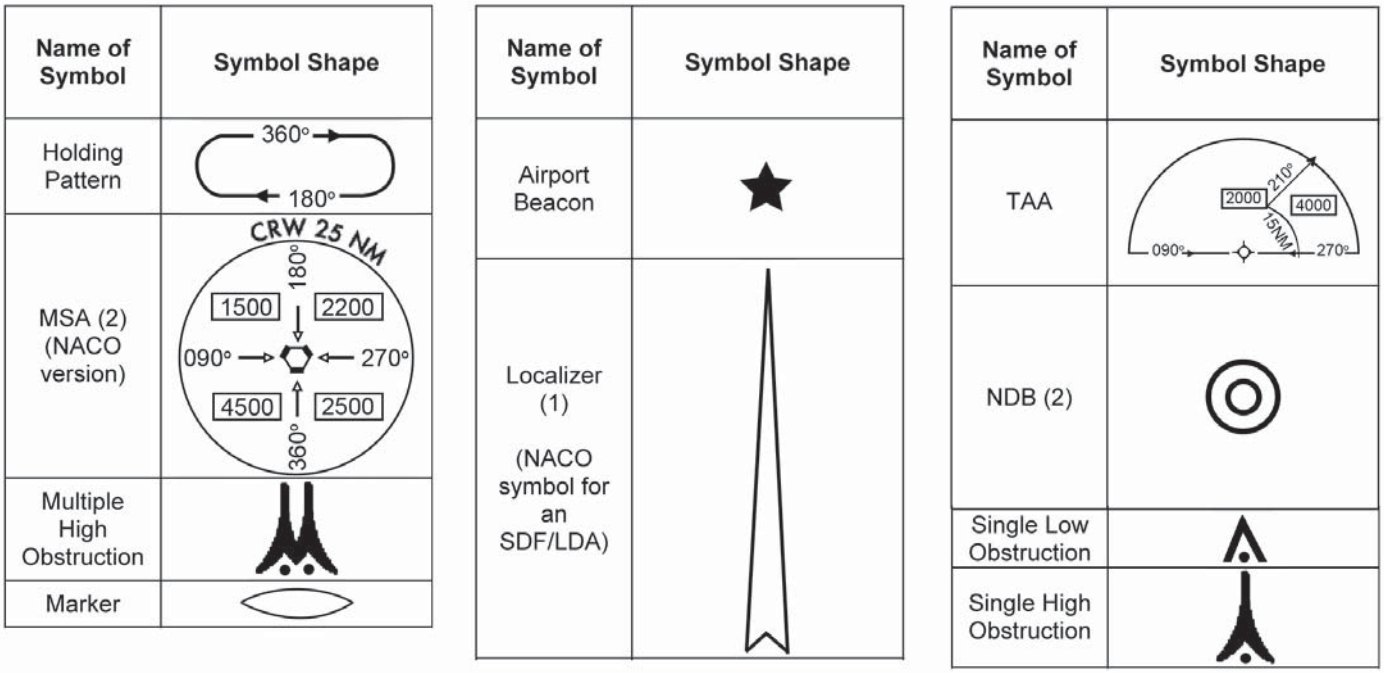
Aerospace systems that adapt to, compensate for, and augment the performance of the human

Flight Symbology

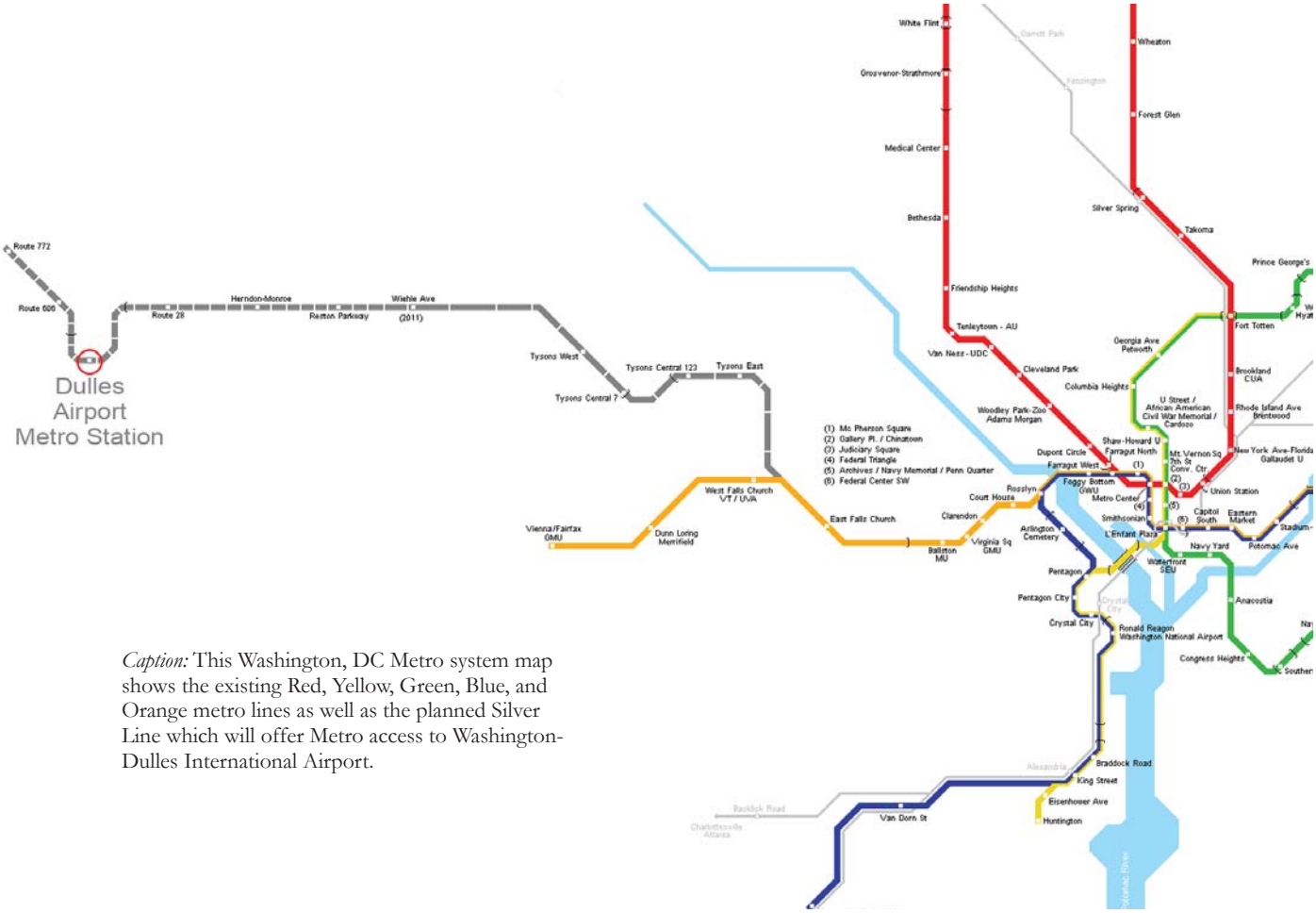
Researchers at the Volpe National Transportation System Center are working with the Society of Automotive Engineers (SAE) International Aerospace Behavioral Engineering Technology Committee (SAE G-10) Aeronautical Charting Committee to update an industry document on recommendations for charting symbology in order to promote consistency across displays, aircraft types, and operations. The Volpe Center is also coordinating research on traffic symbology with the RTCA Special Committee (SC) 186, ADS-B 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, they 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 FY 2007. Results of the study found that pilots use and recognize lines and linear patterns differently based on their qualifications (instrument-rated versus 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 Route Traffic Control Center). Results of this study were documented in a draft report.

Another draft technical report from FY 2007, 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. (Flightdeck/Maintenance/System Integration Human Factors)



Caption: Example navigation-aid symbols and associated shapes



Caption: This Washington, DC Metro system map shows the existing Red, Yellow, Green, Blue, and Orange metro lines as well as the planned Silver Line which will offer Metro access to Washington-Dulles International Airport.

Airport Ground Access Mode Choice Models

Airport ground access mode choice models form a key analytical component of airport landside planning as well as airport system planning. Without an accepted and validated process for predicting how airport users will change their access or egress mode in response to changes in the airport ground transportation system (e.g., changes in fares, rates or service levels) or the introduction of new modes (e.g., extension of a light rail system to the airport), it is difficult to determine the economic feasibility of proposed projects to improve airport ground transportation or effectively manage the existing airport ground transportation system.

These models are highly specialized and not well understood by airport managers, planners, and consultants. With increasing emphasis on intermodal connections as illustrated by the recent Government Accountability Office study on this issue, there is a pressing need for more widely accepted and accessible reference material and guidelines.

This project updated previous efforts to document the state of practice for airport ground access and egress mode choice models. It also addressed the issues involved in the development and use of such models to improve their understanding and acceptance in airport planning and management and provide guidance on their use and development. The research results also serve to focus research and development efforts to continue to improve the state of the art for modeling airport ground access mode choice. (Airport Cooperative Research – Capacity)

Future Terminal Workstation

NextGen will bring substantial changes to terminal airspace in the 2015 – 2025 timeframe. 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 it 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. The FTWS prototype and accompanying traffic scenarios was created. The prototype and scenarios will serve as the platform for human-in-the-loop simulations in FY 2009 through FY 2011.

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. (ATC/Technical Operations Human Factors)

General Aviation Data Collection

Though the FAA, airlines, and their employee representatives have undertaken more proactive approaches to identify risk through Flight Operational Quality Assurance (FOQA) data and internal safety reports, 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.

FAA provided CAMI personnel with information concerning over 150 events. After reviewing the events, CAMI determined that approximately 90 events involved adverse weather encounters such as icing, thunderstorm activity, high winds, or some other weather-related activity 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, so their reaction to these types of events would be different from those who had not previously encountered them. 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 and an annual report that summarized all interviews with pilots. An interview protocol was developed that could be used by Flight Standards Aviation Safety Inspectors. (Flightdeck/Maintenance/System Integration Human Factors, Weather Program)

Operational Voice Communications between Native and Foreign Airline Pilots and Controllers during Oceanic Operations

There is a shortfall in our understanding of operational communications in the en route environment and international voice communications within the 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, the FAA 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.

Five en route facilities were used to provide at least 10 hours of pilot-controller voice communications, with each facility selecting time samples that were representative of peak international (i.e., oceanic) air traffic operations and peak traffic periods with the most communications-intensive operations. Pilot read back errors and communication problems were examined and quantified, and the frequency with which each of the ICAO scales were implicated examined. Fifty-one hours of air-ground transmissions were analyzed. Each controller transmission was paired with its read back and scored for accuracy. In the first of three reports, controller messages were classified according to complexity, message length, and pilot read back accuracy. For the second and third reports, aircraft call signs were used to classify transmissions by aircraft registry (e.g., United States, foreign) and language (e.g., 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.

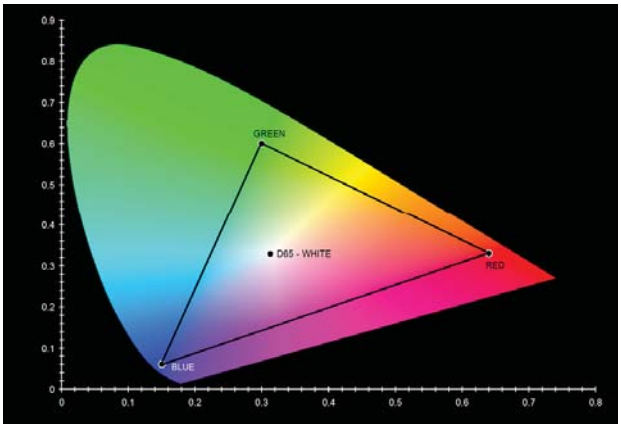
For the first report, 93.8 percent of the pilots' read backs were correct. When an error did occur, pilots experienced more difficulty reading back approach control high-complexity messages than departure control high-complexity messages or low-complexity messages from either approach or departure control. As message length increased, so did the mean number of read back 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 percent U.S., 23 percent foreign) for 4816 pilot transmissions (80 percent English, 20 percent other). In this analysis, 5.8 percent contained problems. When English was the primary language, or pilots flew U.S. 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 were completed: 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 U.S. 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/ATC Procedures. (Flightdeck/Maintenance/System Integration Human Factors)

Air Traffic Control Display Standard – Terminal Color

The FAA Human Factors Design Standard (HFDS) contains 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 is not ATC-specific; for example, it does not provide specific color values for elements appearing on ATC situation displays, such as data blocks and radar targets. The ATC Display Standard - Terminal Color project used human factors standards such as the HFDS to develop detailed human factors color standards specific to the terminal ATC primary situation display.

In the case of color on terminal ATC primary situation 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 can 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.



Caption: CIE 1931 xy chromaticity diagram with sRGB gamut and D65 white point indicated.

In this project, researchers used a spectrophotometer to measure colors used by current terminal ATC primary situation displays as shown on four different monitors. The measurements allowed the researchers to compare the current colors to human factors standards. Researchers evaluated the colors on 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 the researchers identified deficiencies with the current colors, they proposed alternative colors that better met human factors standards.

The project culminated in a final report that contains a detailed standard color palette for terminal ATC primary situation displays 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 final report (DOT/FAA/TC-08/15) describes each display element (e.g., data block, target, map) and specifies a color for that element, expressed in hardware-independent coordinates.

To assist programs in implementing the colors, the researchers have provided hardware-specific coordinates for several existing monitors. This information can be used for the development and acquisition of ATC terminal primary situation displays. (ATC/Technical Operations Human Factors)

Allowable Manual Control Forces in Aircraft Control Systems

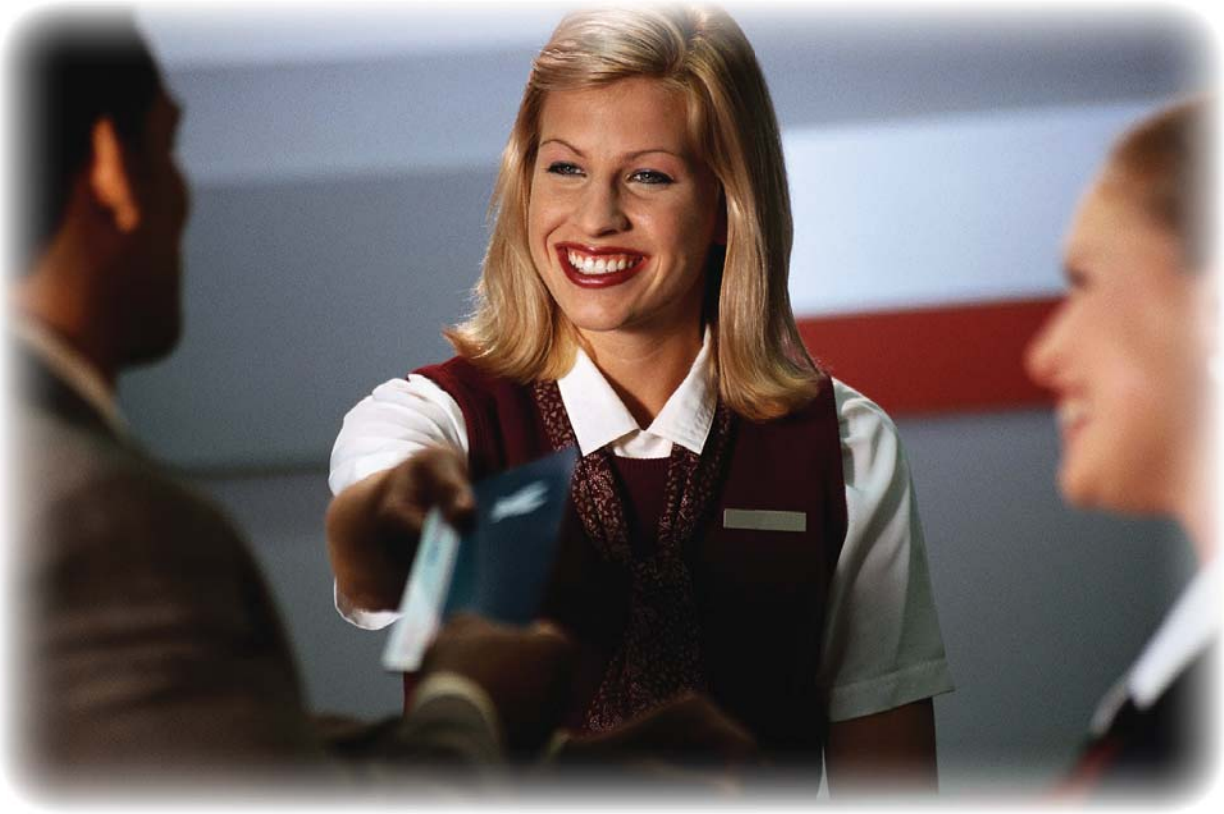
The objective of this effort was to update FAA Regulations 25.143(c) and 23.142(c) with current information based on present and future demographics and current and anticipated control-input devices to be found in part Code of Federal Regulations (CFR) Part 25 and Part 23 aircraft. While the intent was to provide data relating to the maximum forces, both momentary and sustained, that could be exerted by the pilot, information/recommendations were also generated for 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 non-pilots 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 non-pilots (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 meet or exceed the allowable values in the CFR. To a lesser degree, some of the male pilots were also unable to reach tabled force values on some tasks (e.g., foot force). 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 based upon those norms, if the distributions are deemed equivalent. (Flightdeck/Maintenance/System Integration Human Factors)

Assessment of Flight Attendant Fatigue

In 2005, Congress directed CAMI to conduct a preliminary investigation of flight attendant schedules and potential vulnerability to fatigue. CAMI collaborated with NASA Ames Research Center to produce a report in 2006 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.



Coordination of the survey and field studies is underway with Air Transport Association's Cabin Operations Committee, the Regional Airline Association's (RAA) In-flight 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 November 2008 and proceed over a five-month period with a draft report to follow in April 2009.

A CAMI Research and Technical Team was formed to coordinate and accomplish the six recommendations. To date, the following milestones have been accomplished: 1) provided multiple briefings to Regional Airline Association, Air Transport Association, and Coalition of Flight Attendants, 2) developed National Flight Attendant Duty/Rest/Fatigue Survey, 3) obtained Investment Review Board (IRB) and OMB approval for survey, 4) established cooperative agreement for field study, 5) developed National Flight Attendant Duty/Rest/Fatigue Field Study protocol, 6) obtained IRB approval for field study, 7) documented FA policy and regulations from around the world, and 8) obtained more than 2000 Aviation Safety Reporting System incident reports for flight attendants.

The task will continue in FY 2009 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. (Flightdeck/Maintenance/System Integration Human Factors)

Aviation Accident/ Incident Prevention/ Mitigation

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). HFIX includes five broad areas around which interventions can be developed: organizational, human, technology, task, and environment. To assess the utility of HFIX, the current research employed HFIX to address VFR flight into 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 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?). For 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 to increase pilot proficiency and awareness, and installing weather radar in aircraft. A technical report summarizes the results and links previous studies using HFACS with those employing HFIX within a system safety model has been submitted for consideration. (Flightdeck/Maintenance/System Integration Human Factors)

Electronic Flight Bags

Volpe Center researchers are updating and finalizing a draft report on electronic flight bag (EFB)-related safety events to understand how they impact the overall safety of flight operations. Thirty-seven 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, which 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 National Transportation Systems Center to develop Notice N8200.98 (October 2007). The guidance is currently undergoing internal FAA coordination.

Results of the review of EFB-related safety events are described separately for the ASRS data and 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. In ten reports (most of which were from corporate or private operators) pilots mentioned that they were new to the EFB and this may have been a contributing factor in the safety event.

Both NTSB reports identified the use of an EFB for calculating landing distance as a contributing factor. In the first NTSB report (Runway Overrun and Collision, Southwest Airlines Flight 1248, Boeing 737-7H4, N471WN, Chicago Midway International Airport, Chicago, Illinois, December 8, 2005), the key issue 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 (Crash During Landing, Federal Express, Inc. McDonnell Douglas MD-11, N611FE Newark International Airport Newark, New Jersey, July 31, 1997), the key issue was assessment of the adequacy of training and procedures for using EFB performance calculations functions. (Flightdeck/Maintenance/System Integration Human Factors)

Caption: Electronic Flight Bag (EFB) which is displaying the taxiing chart.

Fatigue Assessment under Ultra Long Range Flight Operations

In December 2007 and January of 2008, data was collected from 23 pilots and 20 flight attendants on 10 New York (JFK) to Bombay, India (BOM) ULR flights. Measures included actigraphy (i.e., that monitors when crewmembers were awake and asleep), 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" (aligned with circadian rhythm conducive to sleep) vs. "poorer" (not aligned nor conducive to sleep) 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 required separate comparisons; pilots were scheduled for two sleep-time opportunities en route, whereas flight attendants were scheduled for only one longer sleep-time opportunity; pilots were scheduled for 48 hour layovers versus 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 have been entered into the Fatigue Avoidance Scheduling Tool (FAST™). A briefing to FAA and Delta Air Lines on all results is scheduled for early October 2008. Results provided evidence that the predictions from the modeling tools were generally met and that fatigue and alertness levels varied across the operation and were influenced by the quantity and quality of sleep attained by crewmembers. These results support a continued use of prediction modeling tools in the A332 Operation Specification pre-approval process along with the additional requirement for air carriers to acquire similar data to verify that crewmembers are well-rested during critical phases of flight. (Flightdeck/Maintenance/System Integration Human Factors)

Color Vision Requirements for Pilots

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 FY 2008, the major objective was to document colors used in modern glass cockpits and in the airport environment and to determine whether the current color vision screening tests are adequate, given the increased color usage inside the cockpit.

To do this, a Minolta CS-100 colorimeter was used to create color chromaticity. 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 chromaticity and the range of that chromaticity resulting from use.

Data collection forms, database formatting, and chromaticity display graphs have been completed and 90 percent of the data collected has been screened and entered into the database. Colors were measured in modern glass cockpit displays, including a Boeing 777, an MD-80, and several military aircraft. The chromaticity of airport lighting systems, including the Precision Approach Path Indicator (PAPI), Visual Approach Slope Indicator, taxiway, and runway lights, were measured at 20 airports. Data gathering will continue and include cockpit simulators, airports representing various environmental/climatic zones, additional aircraft manufacturers, and general aviation aircraft. According to data collected at London City University as part of an FAA grant that compared performance on a PAPI light simulator to one of the FAA's color vision screening tests (i.e., Dvorine Pseudoisochromatic Plate Test), the results show that about 93 percent of those passing the screening test were able to identify the red and white lights of the PAPI lights test correctly. (Flightdeck/Maintenance/System Integration Human Factors)

Human Factors Analysis and Classification System Database for Aviation Community Research

The Human Factors Analysis and Classification System (HFACS) is a 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 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 HFACS database will provide access to appropriate FAA officials and committees for needed analyses.

Accident data used in this project were downloaded via records maintained by the NTSB. After several hours of training for the online HFACS database, pilot and mechanic subject matter experts (SMEs) coded finalized NTSB accident indformation into it. 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 analyzed further.

The HFACS 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 GA accidents and nearly 1,500 accidents in the database are commercial accidents. CAMI personnel have conducted detailed analysis of each of the different human error forms (e.g., decision errors, skill-based errors, perceptual errors, violations), and ultra-fine grained analysis on selected error forms.

Discussions were held with the Aviation Safety Information Analysis and Sharing (ASIAS) program office and it has agreed to transition the on-line HFACS database to their network server in the future to foster the sharing and centralizing data among the FAA workforce. (Flightdeck/Maintenance/System Integration Human Factors)

Instrument Procedures

The goal of the first stage of this instrument procedures design project is for the Volpe National Transportation System Center to become familiar with the research issues and various implementation perspectives related to RNP/RNAV. In addition, researchers are working to generate a plan for research activity in this area in collaboration with the project sponsors. 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 provided 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 meet to document and address highly technical and operational issues related to instrument procedures. In addition to participating in these formal group discussions, the Volpe Center has initiated informal discussions with researchers, charting experts, and airline staff about these issues.

Through discussions with the FAA, the Volpe Center 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. Progress towards a coordinated plan for this research was documented in a status report. (Flightdeck/ Maintenance/Systems Integration Human Factors)

Synthetic Vision for Primary and Multifunction Flight Displays

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: 1) 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); and 2) provide data that could be helpful in assessing levels of operational credit that might be granted for the use of such systems.

A survey of the literature was conducted to determine to what extent guidelines and standards for the design and use of pictorial imaging displays (e.g., 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 for Synthetic Vision Systems in the form of a document undergoing final revision and approval in RTCA Special Committee 213 (Enhanced Vision Systems (EVS), Enhanced Flight Vision Systems (EFVS), Synthetic Vision Systems (SVS)), of which the CAMI principal investigator is a participating member. Significant issues were identified that may be important for implementation of EVS, EFVS, and SVS in the NextGen environment, particularly where additional operational credit is sought. (Flightdeck/ Maintenance/System Integration Human Factors)

Native and Foreign Airline Pilots' International Language Experiences

There is a lack of baseline data regarding the effect of language differences of airline transport pilots (ATP) who fly internationally. Research is needed to identify and address the gaps in communications data that may contribute to language issues, communication problems, and procedural differences these pilots encounter. Also, as digital voice communications systems and their applications emerge, it is important to know if they will present problems for non-native English speaking pilots.

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 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 but negligible influence on international aviation; when English language proficiency is deficient it hampers effective communication; and when mixed languages are on frequency, party-line communications pose a safety concern and impede situational awareness. In addition, other findings include: 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; and technological advancements such as data link may help solve some of the language problems. (Flightdeck/Maintenance/System Integration Human Factors)

Pilot Training and Experience with Transport Category Rudder Control Systems

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 provided 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, roll, and yaw axes. 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 CFR Part 25 aircraft certification rules, policy, and guidance; training guidance; and, responses to NTSB safety recommendations. (Flightdeck/ Maintenance/ System Integration Human Factors)

Human Factors Generic Guidance

The Volpe Center submitted a draft general guidance document to the FAA to help 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., 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).

Topics in the document include: address system hardware, display and organization of information elements and features, and design of control devices. A discussion is included on the importance of a design philosophy and considerations for assessing workload, managing errors, automation, and protecting against and managing system failures. The document has two sections. The FAA Requirements and Guidance includes of human factors material excerpted from FAA CFRs, Advisory Circulars (ACs), Technical Standard Orders (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. (Flightdeck/Maintenance/System Integration Human Factors)

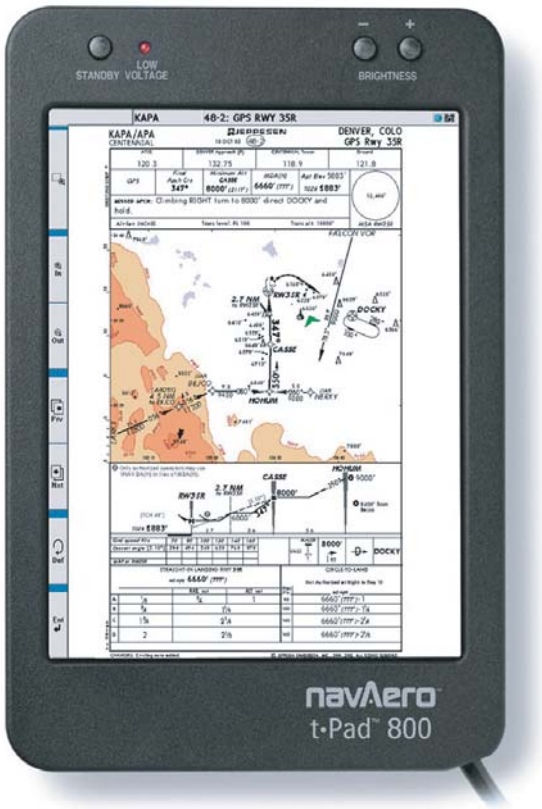
Human Factors Concept of Operations

CAMI 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 ATC system capable of accommodating greater amounts of air traffic while also maintaining or increasing air traffic safety levels above those of today. In support of this effort, researchers conducted two independent studies in parallel. Both relied on an updated hierarchical job/task analysis of en route ATC.

The first study reviewed the current Joint Planning and Development Office ConOps, the FAA Operational Evolution Partnership solution sets, and studies associated with the ConOps that have been performed by MITRE to determine how each ATC 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. (ATC/Technical Operations Human Factors)

Surface Moving Maps

The Volpe National Transportation System Center conducted three activities regarding the 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.



Caption: Electronic chart on an Electronic Flight Bag (EFB)

Caption: Moving-map display on GPS units - installed (left) and handheld (right)

The results of the activities are documented in two draft reports. The first describes causal factors contributing to pilot deviations that led to a runway incursion, provides a brief review of current surface moving map capabilities, and lists areas where research is needed to facilitate the design and approval of surface moving map displays. In particular, there is 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 draft report addresses 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. (Flightdeck/ Maintenance/ Systems Integration Human Factors)

Caption: In-flight moving-map on a navigation display (right and above); airport surface moving-map on a ,ulti-function display (below).

Human protection

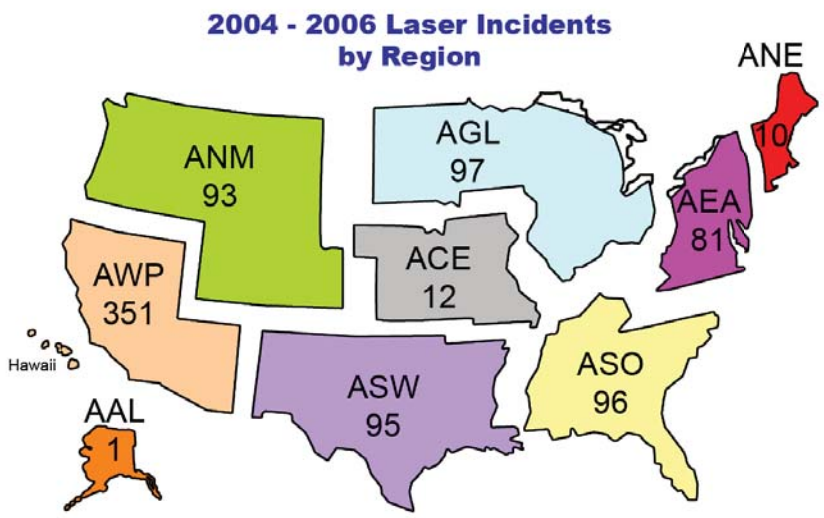
Aerospace systems that adapt to, compensate for, and augment the performance of the human

Laser Illumination of Aircraft by Geographic Location

Incidents involving laser illumination of aircraft in the NAS have raised concerns within the aviation community for more than a decade. The principal concern is the visual effect laser illumination may have on flight crew performance during terminal operations, such as landing and departure maneuvers, when operational activities are extremely critical. A study conducted by researchers at CAMI examined the frequency and rate of aviation-related laser incidents by year and location.

Incident reports of civilian aircraft illuminated by high-intensity lights have been collected from various sources and entered into a database. Reported incidents of laser exposure of civilian aircraft in the United States for a 3-year period (January 1, 2004 to December 31, 2006) were collated and analyzed. A total of 832 incidents during the study period took place within the United States in the nine FAA-designated regions. Total laser incident rates per 100,000 flight operations ranged from zero in the Alaskan region to 0.86 in the Western Pacific Region. Of the 202 airports where laser incidents occurred, there were 20 (9.9 percent) that reported 10 or more laser incidents during the study period. The majority of airports (52.6 percent) with 10 or more laser incidents reported a higher number of incidents in 2005 than in 2006.

Laser illumination incidents that could compromise aviation safety and threaten flight crew vision performance occur with some regularity within the contiguous United States. While the study data indicate the Western Pacific Region had a significantly higher prevalence rate than the other FAA regions, analysis was complicated by incident clusters that occurred randomly at various airports. Actions taken by aviators via notification of air traffic or other authorities, as well as action by local air traffic and law enforcement authorities, can minimize this threat to aviation safety. (Aeromedical Research)



Caption: Summary of all 351 laser incident reports for the 2004 -2006 period by FAA region.

Aircraft Decontamination System

Aircraft provide the ideal environment for the spread of infections diseases on a global basis. The aviation industry expects that the number of passengers flying to foreign destinations will continue to increase. These flights usually involve a large number of people seated together for long periods of time. Further, the materials and surfaces of an aircraft cabin are generally porous and difficult to clean. Finally, viruses, bacteria, and infections may be unwittingly brought onboard and the current decontamination procedures may be inadequate.

The FAA has sponsored two studies through the Airliner Cabin Environmental Research Center of Excellence to assess the feasibility of using a thermal decontamination system developed by the AeroClave Company with a vaporized hydrogen peroxide (VHP) system developed by the Steris Corporation. Specifically, the studies were to determine if the decontamination systems could be operated in an efficient fashion, without requiring bulky vaporizers or other heavy equipment within the cabin and if the system was capable of delivering controlled quantities of VHP such that sporicidal conditions could be achieved throughout the cabin and kill a full spectrum of biological agents.

Field evaluations have been performed on a McDonnell Douglas DC-9 and the CAMI's Aircraft Environmental Research Facility, a grounded Boeing-747. The thermal decontamination system was shown to be capable of reproducing the environmental conditions (temperature and RH) that were found in an earlier study to be efficacious as an antiviral process. It was also found to provide an effective means of achieving environmental preconditioning for the subsequent use of VHP along with aeration after the VHP cycle.

In addition, successful decontamination was accomplished on a rail car. This decontamination technology has potentially multiple applications, such as commercial aircraft, rail cars, buildings, commuter trains, ambulances, and air ambulances. In commercial aircraft, materials compatibility issues must be fully tested and addressed before using VHP and/or Thermal decontamination. VHP and thermal decontamination could affect the continued airworthiness of aircraft and aircraft systems. Even though the feasibility studies showed promise for decontamination aircraft against biological agents and spores, the FAA is not continuing the aircraft decontamination research based on other research priorities. (Aeromedical Research)

Aircraft Overrun and Undershoot Analysis

Recent accidents involving aircraft overruns in Little Rock, AR, Toronto, Ontario, and Chicago, IL have focused attention on improving airport runway safety areas (RSAs) in the United States and elsewhere. Undershoots are also a factor in the design or improvement of RSAs. However, many airports do not have sufficient land to accommodate standard FAA/ICAO recommended RSAs, or they face extremely expensive and controversial land acquisition or wetlands filling projects to make sufficient land available.

The recommended alternatives to a standard 1,000-foot RSA in the United States involve either applying a runway declared distance restriction, with undesirable limitations on aircraft operational payload/range, or installing an Engineering Materials Arresting System with a minimum RSA length of 600 feet. Some airports cannot practically comply with either of these requirements. Current recommendations on standard RSA length are based on a review of all overrun accidents but did not factor in variables, such as the frequency of occurrence and severity of short versus long overruns. More comprehensive research, to include additional variables related to runway overruns and undershoots, would allow more informed decisions on this difficult problem.

This project collected and analyzed historical data related to both overrun and undershoot occurrences in order to assist airport operators in evaluating runway safety areas. The information studied includes accident and incident characteristics such as: aircraft type, occupancy, exit speed, overrun/undershoot distance, weather, elevation, pavement condition, and other characteristics pertinent to the occurrences. (Airport Cooperative Research – Safety)

Turbulence

National Transportation Safety Board data show that turbulence continues to play a factor in more than 25 fatalities per year (mostly in the general aviation sector) and data from National Oceanic and Atmospheric Administration archives show that pilot reports of severe turbulence encounters are more than 4000 per year. To mitigate some of these accidents and incidents, FAA researchers have developed the NEXRAD Turbulence Detection Algorithm (NTDA).

The NTDA provides a new capability to remotely detect in-cloud turbulence using operational weather radar data, thereby supplying a valuable new source of information for a planned nation-wide rapid update nowcast system that will provide a comprehensive diagnosis of atmospheric turbulence hazards from clear air, mountain wave, and thunderstorm sources.

The NTDA makes use of data from the United States network of operational Doppler weather radars to measure in-cloud turbulence. It performs extensive data quality control and uses the radial velocity spectrum width to produce estimates of eddy dissipation rate an atmospheric turbulence metric. During FY 2008, the NTDA was deployed on all U.S. NEXRADs as part of the Open Radar Build 10 software. This data will be used to produce a 3-D in-cloud turbulence map that will be integrated into other turbulence products, including the Graphical Turbulence Guidance Nowcast. The NTDA provides a valuable tool for identifying potentially hazardous regions of in-cloud turbulence. This improvement will allow users to plan more effective and safer routes of flight that will avoid hazardous turbulence areas. (Weather Program)

Side-Facing Seat Crash Dynamics

This project was designed to determine the injury exposure of a human sitting in a side-facing seat during a crash event. It is intended to address the increased use of side-facing seats in the interiors of transport and other category aircraft. The project completed the planned cadaver testing and obtained the necessary data to develop neck injury criteria for side facing seats.

The cadaver testing developed side force information for neck injury, which was not previously available. This testing determined the capability of the human neck in tension and moment loading from a deceleration during a crash while occupying a side-facing seat. The testing was compared to analytical models for the prediction of stresses and strains associated with side impact. The testing revealed that the conventional wisdom of using a three point restraint system may not provide the expected protection. Additional testing is proposed in areas, not thought necessary in the initial test planning, based on this work to complete the stress envelope experienced by the human body in side facing seats. The testing has developed a basic understanding of the dynamics of side facing seat reactions and provided a basis for analysis of side facing seat restraint requirements.

The information obtained from this testing program will provide the necessary human neck side force survival capability to understand the crash condition thresholds for injury while occupying a side facing seat. This will be used to establish reference stress values and correlation standards for the anthropomorphic test dummy to meet side-facing seat certification requirements. (Advanced Materials/Structural Safety)

Icing Forecasting

National Transportation Safety Board reports indicate that in-flight icing causes more than 25 accidents annually, with over half of these resulting in fatalities and destroyed aircraft. This equates to $100 million in injuries, fatalities, and aircraft damage per year. To address this problem, FAA researchers have developed the Current Icing Product (CIP-Severity) and the Forecast Icing Product (FIP-Severity). These products alert users to areas of known and forecasted in-flight icing by graphically displaying the probability that icing will occur along their planned flight path. FIP-Severity was approved by the joint FAA/National Weather Service Aviation Weather Technology Transfer Board for experimental use in FY 2007. User feedback obtained during the experimental phase resulted in improvements, including the addition of more flight levels to the display providing enhanced flight planning information.

FIP-Severity will delineate icing conditions, so that aircraft can avoid these areas. A relative scale has been calibrated to depict the probability of encountering icing and super-cooled large droplet regions, which represent conditions outside the current certification envelopes. These areas are depicted as cross-hatched overlays for quick reference. These capabilities will allow users to plan more effective routes of flight that will avoid hazardous icing areas. Development of FIP-Severity was completed and is expected to be approved for full operational use in FY 2010. (Weather Program)

Terminal Area Safety

The area around terminals continues to be the most hazardous area in the NAS. The majority of accidents occur in the takeoff and landing phases of flight. While capacity issues have become very important, the accelerated introduction of new technology, procedures, and equipment to solve the capacity problems must be integrated into the existing operational infrastructure so that maximum benefits for both safety and efficiency are realized. Examples of what might be involved include aircraft landing performance, terminal area navigation, ATC procedures, controlled flight into terrain on approach or landing, closely spaced runway operations, communication procedures, and airport lighting and signage.

MITRE prepared a report Analysis of Advanced Flight Management Systems (FMS), Flight Management Computer (FMC) Field Observations Trials, Radius-to-fix Path Terminators for FAA. This work was based on a study initiated by the FAA that discussed issues concerning the significance of potential impacts introduced by the differences in performance of various manufactures' FMS and their associated FMC on the terminal area navigation operations.

FAA is also working with the Air Force Research Laboratory's Human Effectiveness Directorate to evaluate the protections and safety procedures for intentional and unintentional laser illuminations occurring in terminal areas during critical phases of flight operations. The goal of the research is to develop procedures and recommended equipment for flight crew and air traffic controllers to mitigate the risk associated with undesired laser illuminations. The FAA conducted pilot-in-the-loop evaluations on laser safety by using the FAA B-737-800 advanced flight simulator equipped with a tracking laser system that realistically mimics a laser flashed at an aircraft flight deck from the ground. The study results will support the development of recommended practices for pilots regarding laser illuminations.

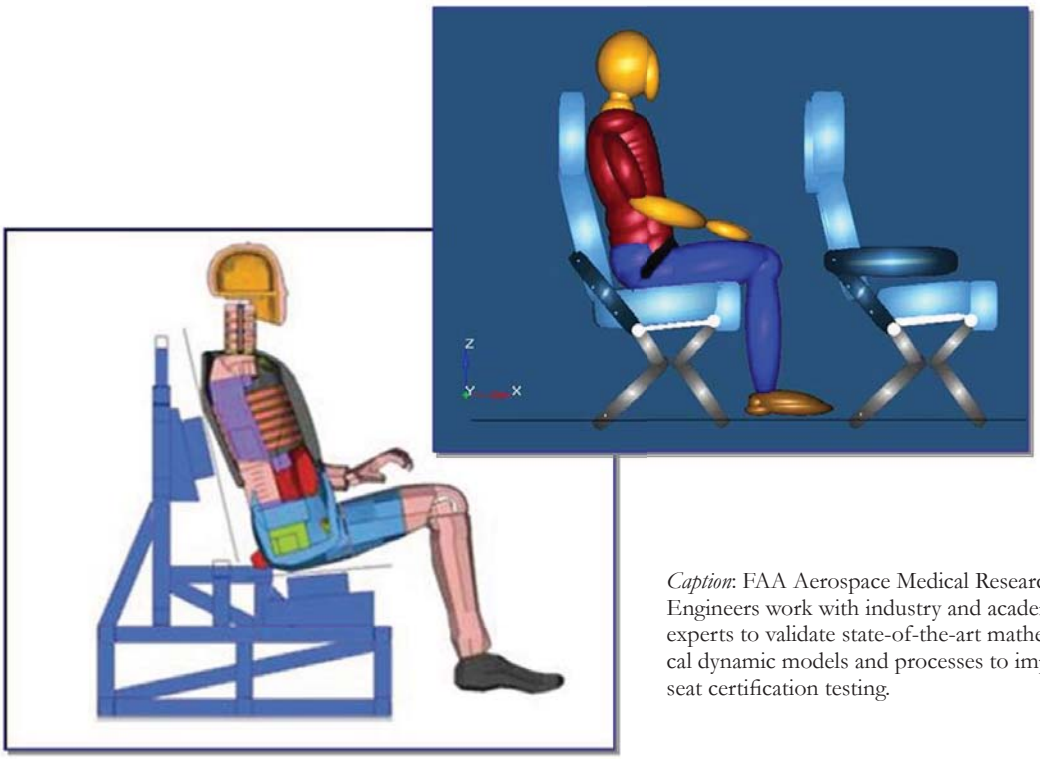
In addition, a draft report entitled Laser Illuminations: Pilot Operational Procedures was submitted to SAE G-10T, the Laser Safety Subcommittee, for final publication. This report offers an overview of the flight hazards associated with laser exposures, and introduces recommended practices to pilots who encounter lasers during flight operations. The technical data contained in the report will provide guidelines for airlines and pilots with effective procedures in response to the visual disruptions associated with low to moderate laser exposures that pilots are most likely to encounter during flight operations. A video on information and instructional operations for pilots during unauthorized illumination events was also completed. Final production of this video will be published by January 2009 to provide reference and training materials for airlines and pilots regarding flight/landing operations during laser exposures. Finally, under a research agreement with the U.S. Air Force, a study was conducted to evaluate various materials for eye protection during laser exposures. Data of the optical density measurements responding to different sources of laser illuminations were collected. The results will be used in follow-up studies to determine effectiveness of laser eye protections. This study will help the aviation industry, including airlines, aircraft manufactures, and pilots develop effective procedures to mitigate risks associated with unauthorized laser illuminations. (Aviation Safety Risk Analysis/System Safety Management)

Occupant Seat and Restraint Models

Aircraft manufacturers are under strong pressure to reduce costs and development cycles in a highly competitive market. The development of aircraft interiors is driven by customer demands, increasingly complex materials, and aviation safety requirements. To address these challenges, engineers and scientists have developed state-of-the-art computational tools and processes to reduce the amount of physical testing, certification costs, and length of regulatory development cycles.

The FAA requires passenger aircraft to have strong seats designed to increase the survivability of passengers and flight crew/attendants in accidents. A 2005 rule, which affects aircraft built after October 2009, states that seats must be able to withstand 16 times the force of gravity (16g), compared with the 9g standard in effect since 1952. Floors and the tracks on which the seats ride also must be able to withstand these forces. The new seats will have to undergo a battery of tests to determine their strength, similar to the crash tests that automakers must comply with to meet federal safety standards. Also, restraint systems that are integrated into and are as strong as the supporting aircraft structure will provide increased occupant survivability.

In conjunction with industry and academic experts, aerospace medical research engineers at CAMI have developed and tested measures of accuracy for dynamic mathematical models. This collaborative effort provides aircraft seat manufacturers with the basis for standardization of dynamic models to support increased safety and reduced cost of seat testing. (Aeromedical Research)



Caption: FAA Aerospace Medical Research Engineers work with industry and academic experts to validate state-of-the-art mathematical dynamic models and processes to improve seat certification testing.

Evaluation and Mitigation of Aircraft Slide Evacuation Injuries

Current technology aircraft evacuation slides may not adequately protect all passengers from injury during evacuations. Airport fire and rescue personnel estimate that approximately 10 percent of evacuees require medical attention for sprains, skin burns, broken bones or other injuries resulting from the evacuation. Evacuation slides are susceptible to problems in deployment during different situations such as high wind conditions, often resulting in the slides becoming rendered useless when folded against the aircraft fuselage and when aircraft are not fully upright when slides are deployed, creating varying slope angles of the slides.

Aircraft in operation today are also of varying ages and aircraft certified over 15 years ago have slide and evacuation rate standards that are very different than newer aircraft, which can affect injury rates. Other factors that can contribute to injuries include whether the aircraft is on or off pavement, the type of clothing worn by passengers, and the differences between single versus dual aisle and single level versus double level aircraft. For larger aircraft, there can be a discrepancy between the evacuation performance of certification volunteers, who are trained in the procedure, and actual evacuees, who often hesitate at the head of the slide, pausing to sit on the door sill before entering the slide. This latter phenomenon results in slower evacuations than is demonstrated in certification.

This project identified the challenges associated with the use of slides at airports, focusing on causes of injury rates and ways to reduce those rates. This comprehensive report includes: a literature review of known incidents where aircraft evacuations via the slides occurred and identified causes of known injuries; a survey/interview of airport operators and emergency responders involved in those incidents, slide manufacturers and aircraft manufacturers, as appropriate; a review of tools relative to aircraft slide evacuations available to first responders; and recommended guidance for airport operators and emergency personnel on preparing for aircraft slide evacuations that includes best practices for minimizing injury rates. (Airport Cooperative esearch – Safety)

Next Generation High Reach Extendable Turret

Past research done by the FAA Aircraft Rescue and Fire Fighting (ARFF) Research Program established the advantages and benefits of ARFF vehicles using High Reach Extendable Turrets (HRETs) equipped with penetrating nozzles in aviation fire fighting. Since the introduction of HRETs in 1986, approximately 400 of the turrets have been retrofitted into existing ARFF vehicles or integrated on new ARFF vehicles. This technology increases passenger survivability, protects property, and extinguished fire faster right after an aircraft crash. Since the current HRET performance criteria have been in place for over a decade, researchers have begun to develop new HRET performance criteria to meet the challenges posed by the new Airbus A380 and other New Large Aircraft.

A 65 foot next-generation HRET has been installed on a research vehicle and a series of non-fire operational tests completed to evaluate its control functions and operations. The live-fire testing of the technology has begun to evaluate the system's fire fighting performance. The objective of testing this new technology is to refine further its performance requirements to meet the challenges of the commercial aviation fleets of today and tomorrow. (Airport Technology Research - Safety)

Informed Consent

To learn more about "informed consent" required by the Commercial Space Launch Amendments Act of 2004, the FAA initiated a project to examine the issue of what a commercial space flight operator will need to do to satisfy the regulatory requirements of 14 CFR Part 460, specifically at § 460.45(a)(1). This section requires a launch operator to inform space flight participants of each known hazard and risk that could result in a serious injury, death, disability, or total or partial loss of physical and mental function.

A report was released that provides background on the origin of informed consent, describes its place in traditional legal framework, discusses how much information should be given to a space flight participant based on past cases, and recommends what a space flight participant should be told about the possible effects of space flight on the human body. To accomplish this portion of the task, the study gathered information on the possible effects on the human body due to space flight. Consideration was given to hazards such as pressure, noise, gravity, temperature, impact, atmosphere, and radiation.

Informed consent is derived from medicine, where doctors must inform patients of any risks or alternatives to a treatment. The patient may then choose to accept or reject treatment. The right of a patient to informed consent has been an important part of medical malpractice lawsuits for over three decades. Some of the principles applied to medicine apply to commercial human spaceflight. As in medicine, the space flight participant must receive enough information to enable an informed decision.

It is important to understand that Congress expressly stated that the emerging commercial human space flight industry was not to be viewed as highly regulated transportation like the airline industry but rather was comparable to adventure travel. Congress even went so far as to compare the participants to daredevils, visionaries, and adventurers. Therefore, the report looked at the standards of informed consent for commercial recreation or adventure sports operators. As with adventure sports, the risks that must be included in any informed consent warnings are those that would affect a reasonable person's decision-making. The greatest emphasis should be placed on the areas with the most frequent or most severe risks. Space flight participants need to be aware, however, that the effects of suborbital flight on the human body are not completely known.

The report summarized the hazards to space flight participants that have been identified by research of space flight experience. It recommends three things.

- The regulation mandates written informed consent. Legally informed consent only provides legal protection, that is, defense, from the risks of an activity and not from negligence. There is some confusion as to whether any private contract that seeks pre-activity exculpation from inherent risks and negligence, which is standard in the adventure world, would be valid. Where the appendices (part 440) to the final rule provide exculpatory style documents in favor of the government as the permitting agency, there is reason to believe that exculpatory documents between a commercial operator and a space flight provider would be allowed.

- Courts differ as to whether a risk is material or not. A material risk is one in which a reasonable operator would provide to a reasonable space flight participant. It is impossible to enumerate every single risk. Clarification of how materiality gets satisfied either by what the operator believes is material or by what the space flight provider thinks is material should be provided. As stated previously, the greatest emphasis should be placed on the areas with the most frequent or most severe risks.

- Collaboration with industry may well be necessary or expedient at this point. Where it has been widely publicized that a leading suborbital provider has signed up literally thousands of prospective space flight participants and has begun working with them, or at least working with some of their "founders," using this early group to determine or establish materiality may well be revealing for industry.

The report and recommendations are provided as an example only. It is recommended that individual operators work with experienced legal counsel for advice tailored to the operator's specific operations. (Commercial Space Transportation)

Drug Usage in Pilots Involved in Aviation Accidents Compared With Drug Usage in the General Population

Forensic toxicology researchers at the CAMI continue to make significant advances in the analysis of postmortem fluids and tissues following fatal aircraft accidents. Its scientists routinely detect and measure drugs, alcohol, toxic gases, and toxic industrial chemicals in the remains of accident victims. Recently, CAMI conducted a research study to compare the usage of illegal drugs and abused prescription medications in pilots involved in civil aviation accidents with that of the general population in the United States.

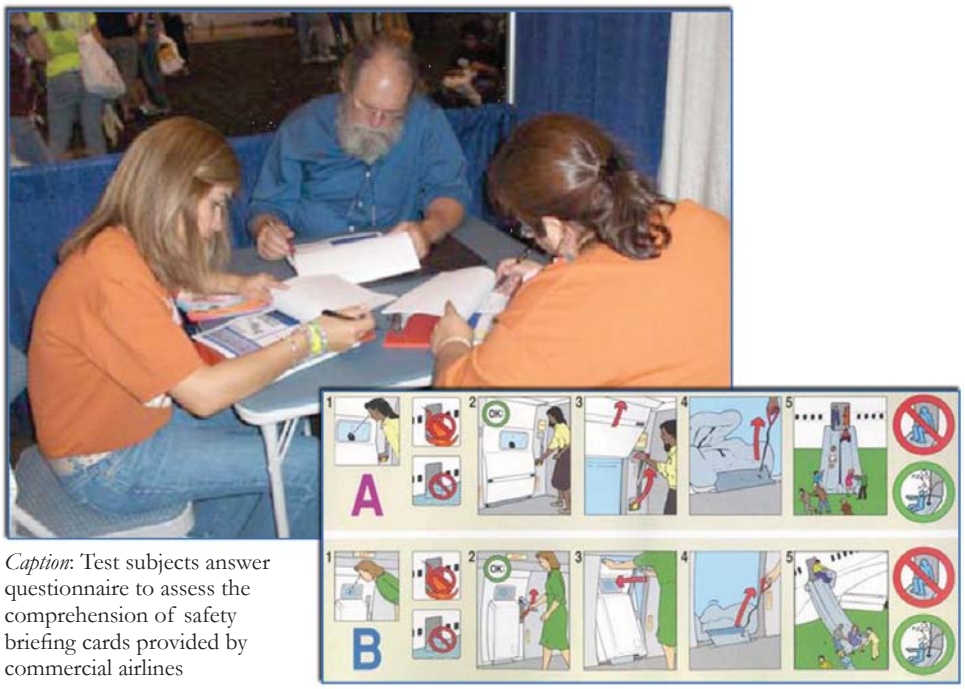
The comparisons included abused drugs routinely screened by the FAA, such as marijuana, cocaine, methamphetamine, and ecstasy, as well as prescription medications, such as barbiturates, benzodiazepines, opiates, and ketamine. Trends in illicit and prescription drug use in pilots of civil aviation accidents were found to be comparable to those seen in emergency departments and community data from major metropolitan areas collected by the Drug Abuse Warning Network and the Community Epidemiology Work Group.

Drug analysis was conducted on 5,321 pilots who were involved in aviation accidents during the examined time period (1990 - 2005). The analysis found 473 occurrences of either illicit drugs or commonly abused prescription drugs, accounting for 9 percent of all pilots. Marijuana or its metabolite, tetrahydrocannabinol carboxylic acid, was the most common compound detected in pilots involved in civil aviation accidents. These compounds were detected approximately twice as often as all other drugs in the study. These research findings are critical to the enhancement of civil aviation medical certification, accident investigation, education, and drug abatement processes. (Aeromedical Research)

Alternative Pavement Grooving Evaluation

An alternative pavement grooving technique, called trapezoidal grooving, was installed and evaluated at two major airports during 2008. This new shaped groove is one quarter or an inch deep and tapers from one-half of an inch wide at the top to one-quarter inch wide at the bottom. It is designed to resist damage from sweeping, snow plowing, and aircraft traffic. The standard groove, which is one quarter inch wide and one quarter inch deep, has historically been susceptible to damage, and is typically replaced after just a few years of installation. Two test sites at Chicago O'Hare International Airport and Quantico Marine Corp Facility were monitored and tested by the FAA throughout 2008. The tests found that the new groove pattern was a great improvement, offering significantly quicker water evacuation, resistance to rubber contamination, improved durability, and similar friction values to those of the standard groove. (Airport Technology Research - Safety)

Comprehension of Safety Briefing Card Pictorials and Pictograms



Caption: Test subjects answer questionnaire to assess the comprehension of safety briefing cards provided by commercial airlines

The presence of fire and smoke is a major cause of passenger and crew fatalities and injuries in airplane accidents. The speed and effectiveness of passenger actions often determines the probability of survival and have been shown to be highly dependent on the information and preparedness passengers have regarding cabin safety and emergency procedures. The safety card in aircraft used to provide much of this information, however, differ significantly among airline operators.

The NTSB has called for both standardization and testing for comprehension of briefing cards. CAMI Protection and Survival Laboratory scientists designed a study to address these recommendations. Among other things, the study gauged the efficacy of current briefing card pictorial components and determined the best presentation techniques for safety briefing cards to enhance the speed and effectiveness of passenger actions.

A total of 358 (46 percent) males and 457 females (54 percent) participated in the study. The participants' commercial flight history, expertise in cabin safety, education level, and other variables were considered. Preliminary findings show that pictorial comprehension scores ranged from 38 percent to 85 percent. Less than half of the comprehension scores exceeded the ISO international standard success criterion of 67 percent and only one pictogram score exceeded the American National Standards Institute criterion of 85 percent. These scores indicate that airline safety cards do not inform passengers of necessary safety information, in part because many cards are too crowded or too complex, which masks important parts of the presentations. (Aeromedical Research)

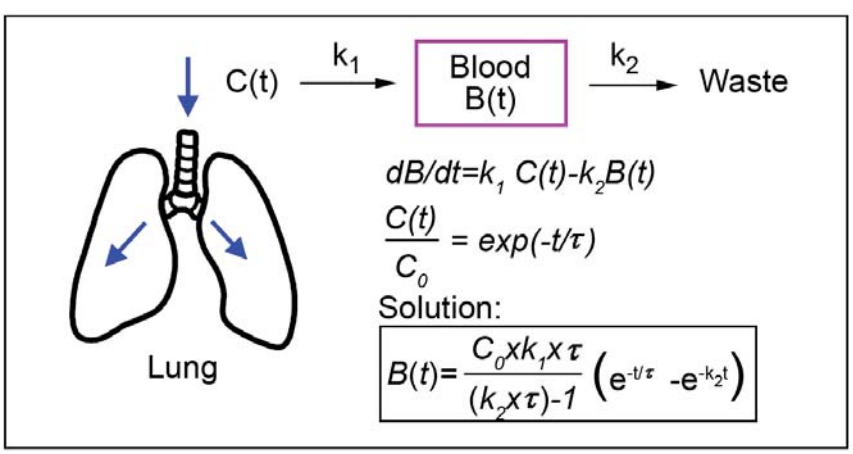
Acute Human Exposure Limits for Gaseous Halocarbon Extinguishing Agents

Effective environmentally-friendly halon replacement agents are available for aircraft hand-held extinguishers. However, the use of these gaseous halocarbon hand extinguishers in the confined space of an aircraft compartment has raised concerns and stymied their use because they can pose cardiotoxic, anesthetic, and hypoxic risks to the occupants of that compartment if excessive agent weights are discharged. Yet, it is of the utmost importance that a sufficient number of halocarbon extinguishers of the proper rating are available to extinguish any in-flight fire that is likely to occur.

A report Safe Acute Exposure Limits for Gaseous Halocarbon Extinguishing Agents in Ventilated Aircraft, DOT/FAA/AR-08/3, was written. It provides a methodology for selecting the maximum safe agent weights for halocarbon hand extinguishers of the required fire rating for use in aircraft compartments based on compartment volume, certificated cabin pressure altitude, and ventilation air change time.

A kinetic model was also developed that provides a simplified method of using existing human physiologically-based pharmacokinetic (PBPK) modeling results for the inhalation of constant halocarbon concentrations to determine the arterial blood intake in a ventilated compartment where the agent concentration is continuously changing. The PBPK data for constant agent concentration exposure was used to determine the first order kinetic rate constants for arterial blood uptake and elimination. In addition, a separate analysis was developed to provide guidance to minimize exposure to low oxygen partial pressures resulting from the discharge of these agents into small unpressurized aircraft compartments.

Arterial concentration histories obtained using first order kinetics provided a good fit to the arterial concentration histories obtained by PBPK modeling for simulated human exposures to constant concentrations of Halon 1301 and the replacement agents Hydroflourocarbon (HFC)-227ea and HFC-236fa. Solving the equation for ventilated compartments for these agents eliminated the need to rerun costly, complex PBPK modeling programs. A good fit was not obtained for the replacement agent Hydrochloroflourocarbon (HCFC)-123, and it was necessary for the manufacturer to run the ventilated PBPK model for this agent. The safe agent weight to compartment volume guidance for halocarbons developed in this report is the basis for the safe-use guidance for halocarbon extinguishing agents in the proposed updated FAA AC 20-42D Hand Fire Extinguishers for use in Aircraft. (Fire Research and Safety)



Caption: Kinetic model of halocarbon transport in the body

Burning Behavior of Cabin Materials

One of the main obstacles to developing ultra-fire resistant materials that impart passive fire protection to transport category airplanes is the lack of understanding of the relationships between the bench-scale fire tests used to characterize the material flammability and the development of a full-scale fire.

To address this problem, the FAA has developed a thermal-kinetic numerical model called ThermaKin that simulates the pyrolysis and combustion of aircraft cabin materials in fire situations quickly and easily using only a personal computer. ThermaKin includes transient energy transport, chemical reactions, and mass transport in the calculation of the one-dimensional burning rate of an object. To calibrate ThermaKin, the FAA measured the chemical and physical properties of several plastics using laboratory (milligram) scale tests and used only these properties to calculate the burning rates of the plastics in a standard bench-scale fire test (ASTM E 1354). Burning rates were then measured of the same plastics in the bench-scale fire test and the results were compared. The comparison between the calculated and measured values was excellent, showing that ThermaKin captures the complex and coupled processes of flaming combustion without any adjustable parameters.

ThermaKin is the first step in the development of a general fire simulation methodology for aircraft cabins under a broad range of fire conditions. Future research will focus on calibrating ThermaKin for charring and composite materials and extending the simulations to 2-dimensions (flame spread) and 3-dimensions (fire growth in an aircraft cabin and fuselage burn-through). The fire simulation methodology will be calibrated at full-scale and, if successful, will provide a tool to assess the impact of ultra-fire resistant materials and material substitutions on the likelihood of an in-flight fire and the severity of a post-crash fire, and will be useful for accident investigation. A description of the model is contained in FAA Report DOT/FAA/AR-TN08/17, Thermo-Kinetic Model of Burning. (Fire Research and Safety)

Powered Air Purifying Respirator Feasibility Study

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 NAS operations. Respiratory protection through the use of power air purifying respirators (PAPRs) is one of the methods that the FAA may use to minimize the spread of disease among staff that cannot function remotely. The goal of this study was to assess the feasibility of conducting maintainer and ATC-type tasks while wearing respirators.

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. To assess feasibility, researchers measured the sound levels of the respirators and their effect on speech intelligibility, visual acuity and field of view, visual detection, ability to perform routine maintenance tasks, and subjective ratings of comfort.

While the researchers found no differences between the PAPRs in visual acuity or field of view, the use of telephones and binoculars while wearing PAPRs ranged from difficult to impossible. The most critical problem identified, however, was the difficulty participants experienced in communication while wearing respirators. The study found significant increases in errors from wearing respirators in the speech intelligibility task with the levels of interference varying from one PAPR to another. Determining the impact of PAPRs on the performance of ATC and maintainer tasks will help in the development of an effective overall crisis contingency plan. (ATC/Technical Operations Human Factors)

Thermal Acoustic Insulation Burnthrough Resistance Certification and Installation Guidance Material (AC 25.856A)

On September 1, 2003, an important FAA fire safety regulation was adopted pertaining to the flammability of thermal/acoustic insulation used in transport category aircraft. The new regulation established two new flammability test methods that were products of FAA research. The first test method measured the resistance of insulation to flame spread from an in-flight fire ignition source and was more realistic and severe than the Bunsen burner test method it replaced. The second test method was a new requirement that measured the ability of insulation to resist penetration, or burnthrough, from a post-crash external fuel fire.

Although the FAA required compliance with the new burnthrough standard in 4 years, industry proposed and was granted a 24-month extension to account for unforeseen test equipment issues that had delayed certification testing. It should be noted that thermal/acoustic insulation is installed very early in the airplane assembly process, so new installations must be implemented well in advance of the actual compliance date, and new designs must be defined well in advance of the installation date. The new compliance date is September 2, 2009.

Although the new burnthrough test method was further developed and refined to maximize its repeatability, many non-test details existed with regard to the installation of insulation blankets in an aircraft. It is important that a blanket meeting the burnthrough requirement be properly installed and attached to the aircraft structure to achieve the full benefit of its fire resistance. A highly burnthrough resistant blanket will be of no value in a crash accident if it is easily displaced during the fire due to insufficient attachment hardware. To ensure all of these additional details were properly addressed, the FAA developed AC 25.856-2.

To date, numerous thermal/acoustic insulation materials have been successfully tested, and these materials can be classified into three basic categories: batting systems, barrier systems, and encapsulating systems. The AC describes each of the system types, and an appendix listes schematic examples of each. In addition, it focuses on specific installation aspects, highlighting key areas that include blanket overlap at frame members, horizontal blanket overlap, penetrations, and types of installation hardware. A detailed test methodology for evaluating the burnthrough resistance of two horizontally overlapped blankets is also included in the AC. The AC also describes the appropriate test methodology for evaluating system performance in case an alternative approach is desired, including a description of the test apparatus modifications needed to evaluate any unconventional approach.

An updated AC, was published (AC 25.856-2A) on July 29, 2008. In addition to the schematic descriptions detailing the proper installation techniques, a detailed description of the new alternative sonic burner is included. The new Next Generation burner was also developed by the FAA, and has distinct advantages over the existing electric-motor-driven burner equipment in terms of output control and repeatability. Although conceptually simple, the new burner equipment requires a fairly robust air compressor as the air source, along with additional heat exchangers and monitoring devices, all of which requires a greater level of description. The new AC contains numerous diagrams and schematics to ensure proper set-up and operation of this equipment.

This guidance material is primarily aimed at airframe manufacturers, modifiers, foreign regulatory authorities, and FAA type certification engineers and their designees. While these guidelines are not mandatory, they are derived from extensive FAA and industry experience in determining compliance with the relevant regulations. An electronic version of the burnthrough AC, 25.856-2A can be found at http://www.airweb.faa.gov/rgl (Fire Research and Safety)

Safe aerospace vehicles

No accidents and incidents due to aerospace vehicle design, structure, and subsystems

Low False Alarm Cargo Compartment Fire Detector Prototype

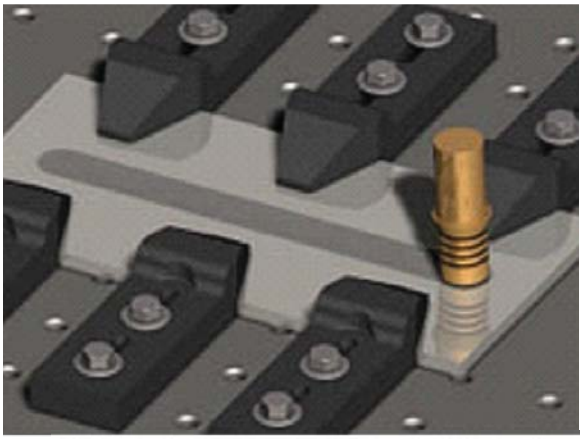
Cargo compartments on commercial aircraft are required to have fire detectors that will alarm within one minute of the start of a fire. The aviation industry currently uses particle sensing smoke detectors to comply with this regulation. These sensors readily detect fires but also alarm to other airborne particles not associated with fires. The ratio of false alarms from existing smoke detectors to the detection of actual cargo fires is on the order of 100 to 1. These false alarms lead to unnecessary flight diversions that are both costly and potentially hazardous.

A test project was completed that developed a series of fire detection alarm algorithms that sense not only smoke particles but also other combustion products including heat, ionized particles, carbon monoxide, and carbon dioxide. The algorithms used various combinations of absolute values of these combustion products as well as rate of change of the values. The algorithms were exposed to a variety of types of fires as well as false alarm sources. One of the alarm algorithms was successful in alarming to all of the test fires in less than one minute and displayed complete immunity to alarming to any of the false alarm sources.

This project demonstrated the potential for multi-sensor fire detectors with an appropriate alarm algorithm, to reduce dramatically the current rate of false alarms without a loss in detection sensitivity. This could lead to a safety improvement by significantly reducing the incidents of aircraft diverting from their intended flight paths due to false alarms from cargo compartment fire detectors. (Fire Research and Safety)

Caption: Cargo Compartment Smoke Detection Test in B707 Fire Test Article

Friction Stir Welded Aviation Structures Design Criteria



Caption: Friction stir welded (FSW) panel in holding fixture during processing (left). FSW panel after diagonal shear test showing capability of the weld (right).

The FAA has certified specific designs for friction stir welded (FSW) aviation structures in the past few years. With the expanding number of processors and structural applications of the process, standardization of the information generated for the process will speed the certification process and allow these rapidly expanding applications to attain a high level of safety without undo cost or complexity. The FAA has worked to leverage the investment in standardization with several industry partners interested in the expansion of the process. The goal is to develop both standardized information on design safety criteria and basic joint allowables to give the structural design community a guide in the safe and efficient use of FSW in aviation structures.

The project started with the basics of determining the critical parameters yielding an effective structural joint that is reliable and durable. An extensive investigation of the parameters which are crucial to the FSW process was conducted. The parameters investigated included feed speed, mandrel rotation, inclination of the tool in relationship to the welded structure, and tool geometry. This study revealed that many parameters initially thought critical did not change the structural performance of the weld. After many experiments it was found that a standard joint configuration can be described that is path independent (i.e., processing parameters do not effect the outcome). In addition, an in-situ rivet process was also found that can be repeated without proprietary processing information. These two developments will be the basis for proceeding with standardization efforts.

This work is the foundation of standardizing the process to develop a joint values that can be compared from location to location to understand the manufacturer's process control; and develop preliminary design capabilities that can be used to evaluate the potential of the process in new applications. The team has initiated efforts to adopt these methodologies in standard practice and material allowable handbooks, such as Metallic Materials Properties Development and Standardization. (Advanced Materials/Structural Safety)

Surface Condition Determination for Reliable Processing for Bonded Structures and Repair

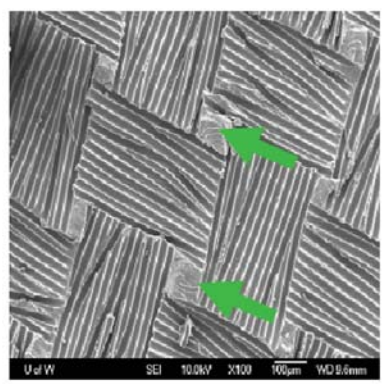
The expanded use of composite materials in structural applications has focused attention on repair procedures for those products. The use of bonding for repair of composite structures is preferred for maintaining integrity of the parent structure. There are concerns with the use of bonded repairs, especially in the aircraft operations environment, due to surface cleanliness requirements for bond reliability and durability. The structures are typically contaminated with dirt, oils, and greases from the operating environment. These are known to cause severe problems with adhesion of the repairs.

This work has investigated the chemical interaction of the surface and the adhesive materials; identified the most probable contaminates; assessed the impact of those contaminates; and identified the possible means of detecting the level of contamination from the repair surface. The FAA has been assessing the ability of current and innovative detection equipment to identify the specific contaminates and the capability to determine whether the contamination level is acceptable to establish a durable bond.

This project identified the surface contaminates which cause degradation; documented technologies which identify the surface contaminates; and evaluated initial equipment able to assess surfaces for those contaminates. This work will allow applicants and operators to provide repair procedures that incorporate reliable methods for accurate determination of surface suitability for durable structural bonds. This will enable the use of more bonded structure in future aircraft while providing expected level of safety. (Advanced Materials/ Structural Safety)

a)

b)



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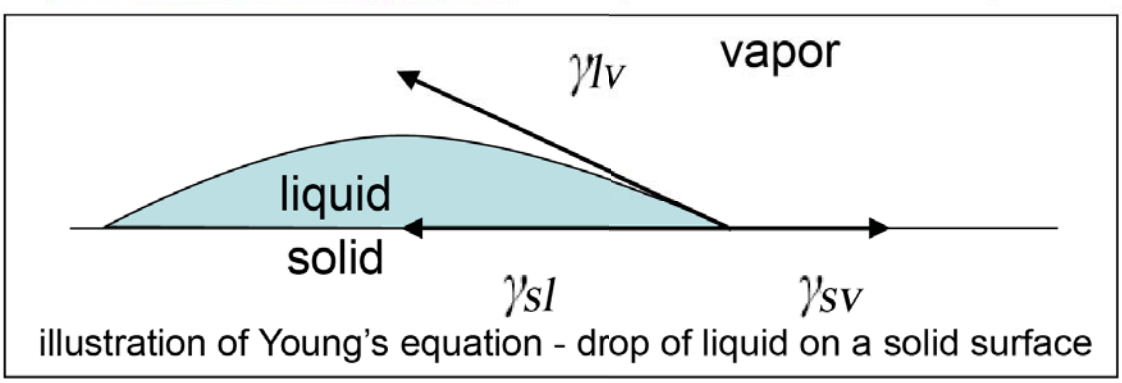


Caption: a) Handheld inspection wand for determining surface condition. b) Surface analysis showing peel ply residue which could effect durability of bond. c) Determination of surface condition by contact angle between surface and liquid (typically water) drop on surface.

Microprocessors Evaluations for Safety-Critical, Real-Time Applications

Despite their extensive use in the aerospace industry, there is a lack of safe, economical methods to evaluate the reliability of microprocessors for safety-critical aerospace applications. The purpose of this research is to: investigate microprocessor use in the industry, identify assessment criteria for microprocessors, and document safety concerns for microprocessors. It identifies methods to evaluate microprocessors for safety-critical applications. Effective criteria for determining what is a high-risk versus low-risk microprocessors do not exist. The risk is the risk of microprocessor failure in critical applications that may endanger life and property, because of a resulting aircraft accident. If this research is not performed, the ability of the FAA and industry to evaluate emerging, highly complex digital hardware and software for use in advanced flight controls and avionics systems will be jeopardized, the cost of certification for the FAA and industry will increase, and the level of assured safety will be at risk. Certification specialists will find it difficult to properly assess proposed aircraft and avionics designs which employ this technology in flight essential and flight critical applications.

This research will: develop methods and procedures to permit the safe, economical qualification of microprocessor applications with complex, nondeterministic architectures; provide criteria to select microprocessors for safety critical aerospace applications that can be proven to be safe; and provide technical data for the development of FAA regulations and policy for the design and test of commercial-off-the-shelf (COTS) microprocessor components.

The 2008 report Microprocessor Evaluations for Safety-Critical, Real-Time Applications: Authority for Expenditure No. 43 Phase 2 Report, (DOT/FAA/AR-08/14) includes an in-depth analysis of functional test and validation of microprocessors, emerging microprocessor features safety issues, system on a chip (SoC) safety issues, and nondeterministic approaches to demonstrate safety evidence. The report provides an evaluation of modeling techniques proposed as a part of the Microprocessor Approval Framework (MAF), an assessment of the feasibility of using third party simulation tools for microprocessor and SoC safety analysis, and an evaluation of the applicability of the proposed MAF to COTS microprocessors. The MAF is the microprocessor approval framework that provides a procedural framework for new ways to evaluate these microprocessors and new ways to provide additional safety risk mitigation techniques.

In addition, a draft report was completed that contains the results of using MAF to assess the COTS Freescale MPC7447 microprocessor and the Freescale MPC8540 SoC as well as an evaluation of the Buffer Oriented Micro-architectural Validation (BOMV) technique for micro-architectural features of COTS microprocessors. (Atmospheric Hazards/Digital System Safety)

Geometry Conversion Tool for Rotorburst Vulnerability Reduction

Users of the Uncontained Engine Debris Damage assessment Model (UEDDAM) have had difficulty converting commercial aircraft geometry into the Fast Shot-Line Generator (FASTGEN) format used by the UEDDAM analysis code. Discussions with industry indicated that a converter from PATRAN was needed to decrease the time required to build the models for commercial users.

A FASTGEN preference was developed to support this request. The converter preserves the geometry and material identification of components and helps users build a vulnerability analysis model that can be used for either an infinite energy rotorburst analysis per the current FAA Advisory Circular (AC 20-128A), or the multiple fragment Monte-Carlo analysis anticipated for future designs. (Aircraft Catastrophic Fire Prevention Research)

Integrated Modular Avionics Research

The combination of rigorous design and verification assurances has led to safe and reliable operation of civil aviation software and digital systems. Historically, in typical federated systems, integration was a rather straight forward activity involving compiling, linking, and loading the software application onto the target computer system environment. However, Integrated Modular Avionics (IMA) systems and their ability to integrate several functions with shared resources require further guidance.

The 2008 Handbook for Real-Time Operating Systems and Component Integration Considerations in Integrated Modular Avionics Systems (DOT/FAA/AR-07/48) is designed to inform the IMA system development role players of their commitments to each other and to the operational system. Its purpose is to aid industry and the certification authorities in the earlier integration stages of IMA system development. As such, this handbook documents some currently known issues, practices, and activities to be considered in the development and verification of IMA systems. These activities and practices include a discussion of modeling, the use of tools, and other IMA system development topics.

Information from the handbook is included in several publications: RTCA Special Committee SC-200 in the development of RTCA/DO-297 Integrated Modular Avionics (IMA) Development Guidance and Certification Considerations; and AC20-145, Guidance for Integrated Modular Avionics (IMA) that Implement TSO-C153 Authorized Hardware Elements. (Atmospheric Hazards/Digital System Safety)

Propulsion Malfunction Research

The FAA has an ongoing, multi-year effort to study propulsion malfunctions that precipitate inappropriate crew response type accidents and incidents. This effort is in response to research recommendations from a 1998 Aerospace Industries Association (AIA) report. The Engine Damage Related - Propulsion System Malfunctions, study, completed in 2007, directly supports the AIA Propulsion Indications Task Team (PITT) that is working to develop recommendations for future changes in the Federal Register, Title 14, CFR Part 25.1305. This research provided input for the propulsion section of recently published FAA Advisory Circular (AC25-11A).

The 2008 study developed concepts for information based oil system displays with the intent of minimizing crew troubleshooting in the cockpit and tying information to actions and checklists for the pilots when required. The study focused on the pilot informational needs and looked at the best means of displaying the information. Four concepts were developed and programmed into the Boeing 777 CAB simulator. Work is continuing in support of the AIA PITT team with the evaluation of the developed information based display concepts that will tie annunciations to pilot actions and minimize troubleshooting of propulsion malfunctions in the flight deck. (Aircraft Catastrophic Fire Prevention Research)

Caption: Dr. Mosinyi performing a baseline nondestructive inspection for multiple-site damage on a fuselage panel.

FAA-Drexel Fellowship

The FAA-Drexel Fellowship Program is a collaborative effort established in 1998 to promote aviation safety within academia and support ongoing research activities within the Airport and Aircraft R&D Division. Participating students are an integral part of the program and have the opportunity to solve real-world problems that face the aviation industry. The goal of the FAA-Drexel fellowship program is to promote and train the next-generation engineer addressing aircraft safety issues.

On Oct. 17, 2007, FAA-Drexel Fellow Bao Mosinyi became the second Ph.D. graduate from the FAA-Drexel Fellowship program. The research for his dissertation, "Fatigue Damage Assessment of High-Usage In-Service Aircraft Fuselage Structure," deals with multiple-site damage (MSD), a critical safety issue of aging airframe structure facing the aviation industry today. Dr. Mosinyi's research involved complicated extended fatigue tests of two fuselage panels removed from a retired B727 airplane at the FAA Full-Scale Aircraft Structural Test Evaluation and Research facility. This research will provide key information for the aviation industry in developing programs to prevent the occurrence of MSD in the aging aircraft fleet. Dr. Mosinyi has accepted a position with Airbus North America in Wichita, Kansas.

The first Ph.D. graduate from the Program accepted a position with Boeing Commercial Aircraft Company in Seattle, Washington, in 2006. (Continued Airworthiness/Aging Aircraft)

Turbine Engine Research

The FAA is working with the aircraft engine industry to develop an enhanced life management process, based on probabilistic damage tolerance principles, to address the threat of material or manufacturing anomalies in high-energy rotating components. An integrated team of Southwest Research Institute, GE Aviation, Pratt & Whitney, Honeywell, and Rolls-Royce Corporation developed a probabilistically-based damage tolerance design and life management code called Design Assessment of Reliability with Inspection (DARWIN) to determine the risk of fracture of turbine engine rotors containing undetected material anomalies.

The initial version of DARWIN addressed the subsurface material defect known as hard alpha and meets the requirements of a new FAA Advisory Circular on Damage Tolerance for High Energy Turbine Rotors (AC33.14-1). In FY 2007, a new version of DARWIN was completed to address surface damage in bolt holes and, in the following year; another new version was delivered to address surface defects on the turned surfaces of rotor disks. The FAA plans to complete new Advisory Circulars based on these new versions of DARWIN. Future versions of DARWIN will address surface damage in blade slots as well as advanced zoning capabilities and advanced probabilistic methods to treat varying inspection schedules and multiple defects. (Aircraft Catastrophic Fire Prevention Research)

Qualification of Airborne Electronic Hardware Tools

This research initiative identified potential safety issues in the assessment and qualification of design and verification tools that are used to develop certain airborne electronic hardware (AEH), previously called complex electronic hardware (CEH), for the aircraft. The quality of the design and verification tool and the assurance provided by the tool are critical for the approval of any aircraft system containing this AEH. The AEH covered are custom, micro-coded components or devices, such as programmable logic devices, field programmable gate arrays, application specific integrated circuits, and similar circuits used as components of programmable electronic hardware. Neither the avionics standard RTCA/DO-254, Design Assurance Guidance for Airborne Electronic Hardware, nor three Certification Authorities Software Team (CAST) papers (CAST-27, 28, and 30) written to clarify portions of RTCA/DO-254, specifically define what a design and verification tool for AEH is.

A 2008 draft report was developed to document the Phase 1 findings and results of the research. The research was conducted in several steps including literature search; industry survey; identification of primary aircraft safety; performance and certification concerns; developing plan for validating these concerns; conducting experiments with the tools; and evaluating the experiments. The report addresses concerns related to approaches used to qualify tools used in the design and verification of AEH for airborne applications; service experience or service history used in AEH tool qualification; the potential role of the Testing Maturity Model (TMM) in tool qualification; and the impact of commercial off-the-shelf AEH on the aircraft system and AEH tools. Some of the concerns include ease of using the tool for verification, quality of the tool, and the speed with which the tool verifies designs. These concerns could be significant problems depending on the manufacturer's use of the tool and the part that the tool plays in its use within the development or verification process. Complexities with insuring independence of the verification effort, dealing with unused inputs and outputs, and solving timing issues are sample results from this research that are high on the list for resolution and review by applicants. These findings and results were presented at the 2008 FAA National Software and Airborne Electronic Hardware Standardization Conference.

The TTM provides an additional process to consider for the evaluation of AEH tools. The report documents this role through discussion of applicable TMM characteristics in the tool verification process. The research looked at the testing and verification process in the areas of testing phase definition, integration testing, the management and measurement of testing, and testing optimization and detection. The results found that TMM results may need to be reviewed independently to confirm that proper procedures were followed and that results adequately verify that the requirements have been met.

This research supports policy and guidance development for aviation systems in a rapidly evolving field of technology that exhibits a proliferation of AEH and software tools. (Atmospheric Hazards/Digital System Safety)

Unleaded Fuels and Fuel System Safety Research

The EPA exemption of general aviation from the 1990 Clean Air Act Amendments regarding the use of leaded fuel is still in effect. Recent petitions to the EPA have reignited the call for either a ban on leaded aviation fuels or a study on the health effects of leaded aviation fuels. It is likely that environmental and cost pressures of using leaded fuels will continue to increase for the general aviation community. Extensive testing by the FAA William J. Hughes Technical Center on an unleaded replacement for the current leaded 100 low-lead (100LL) aviation gasoline involved the use of specialty chemicals. Significant engine modifications may be required on the high-compression engine legacy fleet to operate on a lower-octane, unleaded fuel, which would likely result in changes to engine and aircraft performance and pilot-operating procedures. Recent FAA tests confirmed that significant detonation performance differences exist between unleaded and leaded fuels of the same octane. The FAA, therefore, needs to continue its research on unleaded fuels and to evaluate engine technology given the increasing safety and certification concerns with the use of alternative fuels.

Working in parallel with the Coordinating Research Council, the FAA Propulsion and Fuel Systems Team was supplied with 47 separate blends of unleaded fuel containing various amounts of aviation alkylate, super alkylate, Toluene, Ethyl-tert-butyl-ether, tert-Butyl benzene, and meta-Toluidine. All blends contained 5 percent Isopentane. The blends' compositions had motor octane numbers (MON) ranging from 97.6 to 106.3, and did not meet the current American Society for Testing and Materials (ASTM) D 910 leaded aviation gasoline specification. These 47 blends, along with a specially blended, minimum specification 100LL and unleaded reference fuels, were detonation-tested in a Lycoming IO540-K engine at the FAA William J. Hughes Technical Center. The goal was to address both the individual and synergistic compositional effects of the unleaded components on the full-scale engine detonation performance and on the ASTM D 2700 laboratory MON. The MON was correlated to the full-scale engine detonation performance and compared to the detonation performance of the specially blended 100LL.

Four power settings, ranging from takeoff to economy cruise, were evaluated with fuel mixture strength varying from 0.600 brake-specific fuel consumption to 50°F lean of peak exhaust gas temperature. Results show that the MON of the blends did trend with their detonation performance in the IO540-K engine, but equivalent unleaded blend performance of the specially blended 100LL required 2.0 greater MON. Nineteen of the 47 blends, all with higher than 102.5 MON, provided better detonation performance than the specially blended 100LL. Fourteen of the blends had higher MONs than the 100LL but performed worse in the full-scale engine. (Aircraft Catastrophic Fire Prevention Research)

Cargo Fire Suppression Effectiveness of a Halon 1301/Nitrogen Enriched Air Mixture

The FAA Halon Replacement Program continues to investigate ways to eliminate or reduce the amount of Halon 1301 used in aircraft cargo compartments. In the past, the FAA has tested plain water mist, water mist combined with nitrogen, HFC-125, HFC-227, 2-BTP, and FK5-1-12; water mist combined with nitrogen was the only fire suppression system able to meet the FAA minimum performance standard (MPS) acceptance criteria. Since water mist/nitrogen systems are still under development, the FAA Fire Safety Team has been evaluating transitional techniques to reduce the use of Halon 1301 onboard the aircraft cargo compartment. One such technique is to introduce

Caption: High Pressure Vessel (left) and exploding aerosol can simulator (right)

nitrogen into the cargo compartment, using the aircraft fuel tank's onboard inert gas generation system (OBIGGS) to replace the fire suppression system metering phase (second discharge stage) of Halon 1301. There is, therefore, interest in determining the effectiveness of a mixture of Halon 1301 (first discharge) and nitrogen from an OBIGGS.

The experiments were conducted in the High Pressure Vessel Facility at the FAA William J. Hughes Technical Center. The facility had a 402.6 ft3 pressure vessel instrumented with thermocouples, pressure transducers, gas analyzers, and a video camera. In the past, the exploding aerosol can simulator test requirement in the MPS was the primary determinant of the potential feasibility of a halon replacement agent. Therefore, the FAA aerosol can explosion simulator was installed inside the pressure vessel to conduct the tests. It contained a mixture of propane, alcohol, and water to simulate the contents of a large commercial aerosol can (i.e., hairspray). A wide range of nitrogen (to reduce the oxygen volumetric concentration) and Halon 1301 mixture concentrations were discharged inside the pressure vessel. After achieving the required oxygen and Halon 1301 concentrations, the aerosol can explosion simulator was activated to attempt to create an explosion. Temperature, pressure, and gas volumetric concentrations were recorded with a 1 Hz and a 1 kHz analog to digital data acquisition systems.

This research showed that beneficial effects resulted when Halon 1301 and nitrogen were combined to inert a closed pressure vessel (compartment) against an explosion from an aerosol containing propane, alcohol, and water. Less Halon 1301 was needed to inert a compartment having an oxygen-depleted environment. Explosions were prevented when these two gases were combined at concentrations that were below their individual inert concentrations. For example, an explosion was prevented when the volumetric concentration of Halon 1301 was 1 percent and the oxygen concentration was 17 percent. Individually, the required inert concentrations would be about 3 percent Halon 1301 and 12 percent oxygen. This means that in a typical aircraft cargo compartment fire protection system configuration, with a dual-stage discharge (high-rate/low-rate discharge), it may be more feasible to replace one of the two Halon 1301 fire bottles because of the availability of a nitrogen generator system. This approach would be particularly attractive in an aircraft with an available onboard inert gas generation system to prevent fuel tank explosions. The system integration could reduce the amount of Halon 1301 from the aircraft cargo compartment fire suppression system by 50 percent or more. (Fire Research and Safety)

In-flight Fire Exposure of Aluminum and Composite Fuselage Materials

Modern civilian transport aircraft are being constructed with increasingly greater portions of the aluminum fuselage being replaced with composite materials. The Boeing 787 is a nearly all composite aircraft. Composite materials consist of layers of fiber material held together with a resin binder. They have many benefits for the aircraft manufacturer in terms of fabrication strength and weight savings. The performance of these materials under in-flight and post crash fire conditions, however, is essentially unknown. Aircraft have been constructed with aluminum skin and structure for decades. The performance of this material when exposed to an in-flight or post crash fire is well known. Aluminum is essentially non-flammable, conducts heat very well, and has a high thermal radiation coefficient. Aluminum also melts at a relatively low temperature. These properties cause the aluminum hull material to behave very differently during an in-flight fire versus a post crash fire. During in-flight fire exposure, the aluminum skin and structure of the fuselage are cooled by the flow of air around it. This keeps the metal below its melting point and preserves the structural integrity of the aircraft. There has never been a documented case of hull penetration due to in-flight fire in an aluminum aircraft.

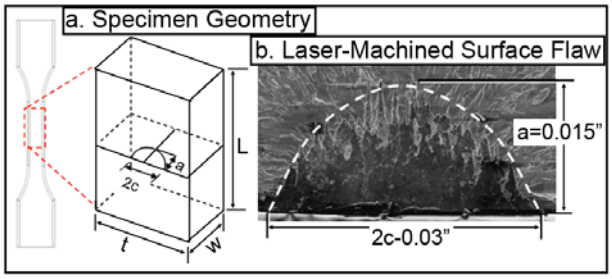
Caption: Test fixture mounted in wind tunnel

The FAA William J. Hughes Technical Centers Airflow Induction Facility performed a series of tests to determine the relative performance of both aluminum and composite hull materials when exposed to an internal fire while in flight. A test fixture was designed to simulate in-flight airflow over the test panels. The underside of the fixture was fitted with an enclosed box that housed the heat sources. Two heat sources were used to expose the underside of the test panel, an electric heater, and a live fire. The electric source was used to determine the relative heat conduction properties of each type of material under ground and in-flight conditions. The live fire intensity was sized to expose the test panels to a condition that was severe enough to melt through the aluminum panel under ground conditions, but not in-flight. The aluminum and composite test panels were exposed to each of these heat sources under airflows that simulated both ground and in-flight conditions. The heat transfer and conduction properties were measured with both thermocouples and forward-looking infrared cameras.

The results from these tests show that there is no significant loss in fuselage structural integrity during an in-flight fire due to the use of composite construction verses aluminum construction. The materials conduct and transmit heat very differently; however, the resistance to burn through is similar. The aluminum panels behaved as observed from experience in full scale aircraft fire tests. The aluminum transmits heat in a radial direction very effectively. Aluminum is also very effective at convective transfer of heat to air, more so in a moving air stream. If sufficient heat is applied to overwhelm these characteristics, the panels become plastic and deform when nearing the melting temperature of 1,220o F. Once this temperature is reached, the metal turns to liquid, leaving a hole in the panel. Burn through under our test conditions occurred in 12 - 15 minutes. Burn-through is not an issue during in-flight conditions. The air stream is sufficient, even at the relatively low 200 mph in these tests, to cool the top surface of the metal and prevent it from reaching the melting point.

This has been demonstrated in real world aircraft fires; burn through occurs on the ground once the relative airflow has stopped. Although composite panels do not appear to transmit heat effectively in a radial direction, they do transmit heat normal to the surface. The panels are effective at preventing burn through, even though the resin is flammable because they have some insulating effect. Topside temperatures in the static tests were roughly half of the underside temperatures. The fire does damage the exposed face of the panel, burning the resin away and exposing the fiber. Once the outer layer of resin is burned away, however, the exposed fiber material acts like a fire blocking layer, limiting further damage. Burn through did not occur within the time frame of these tests, up to 25 minutes. Airflow over the panel during in-flight conditions is very effective at cooling the top surface of the composite material. The top surface temperature was lowered by more than 200o F in 200 mph airflow. Off gassing from the heated composite panel did produce a flammable mixture in the box resulting in a flash fire. Further work in this area is needed to determine the magnitude of this hazard and the implications on safety. (Fire Research and Safety)

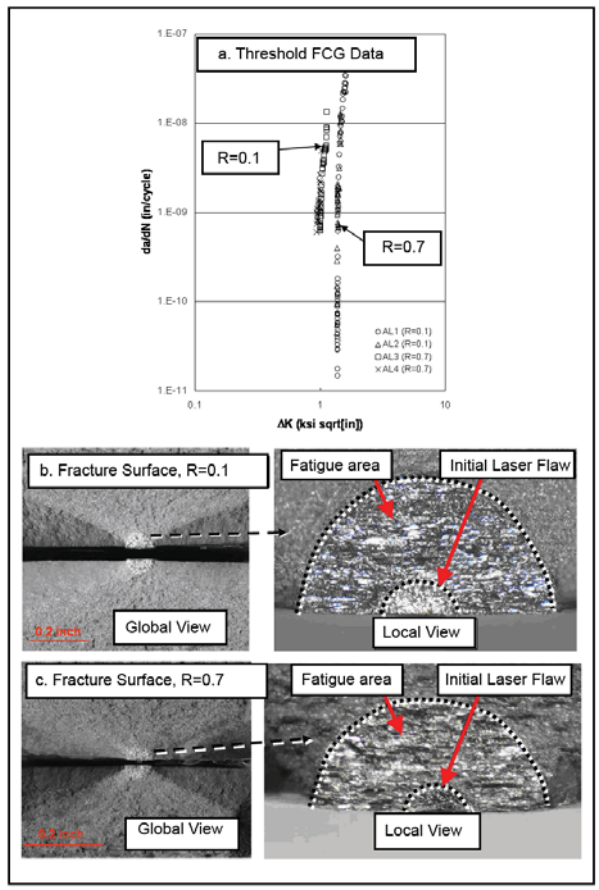
Characterization of Fatigue Crack Threshold in High-Cycle Fatigue Applications



Caption: Specimen configuration: a.) Dog-bone geometry with a semi-circular surface flaw and b.) Surface of laser-machined notch.

Aircraft propeller blades operate in a high-cycle fatigue (HCF) environment, accumulating a large number of fatigue cycles in a short period of time. Due to HCF, stable fatigue crack growth is of relatively short duration. For practical damage tolerance applications, it is desirable to operate propeller blades below the threshold region of fatigue crack growth. Traditional damage tolerance analysis uses near-threshold fatigue crack growth data from large cracks obtained mostly from compact and middle tension test specimens. However, in the case of aircraft propeller blades, the primary concern is the damage tolerance of small surface flaws. Therefore, this research program focuses on near-threshold fatigue crack growth of small, thumbnail-like, surface flaws in 7075-T7351 aluminum used in aircraft propeller blades. Of interest is the effect of compressive residual stresses at the outer surface of the specimens, introduced by shot-peening, on the near threshold fatigue crack growth behavior of small surface flaws.

The tests were conducted using dog bone specimens, as shown in Figure 1a, at the Material Characterization Laboratory located at the FAA William J. Hughes Technical Center, Atlantic City International Airport, New Jersey. A closed-loop, servo-hydraulic axial test stand with a 50-kip maximum capacity was used under load control mode, in accordance with ASTM E 647. To simulate the effect of small surface flaws (such as initial manufacturing flaw, in-service mechanical damage, and in-service corrosion damage), small 0.015-inch-radius semicircular surface flaws were introduced using a relatively new laser-machining technique, Figure 1b. The Direct Current Potential Difference method was used to monitor the subsequent fatigue crack growth (FCG). Initial and fatigue crack front profiles were measured using a stereomicroscope, optical microscope, and scanning electron microscope, at the end of the test.

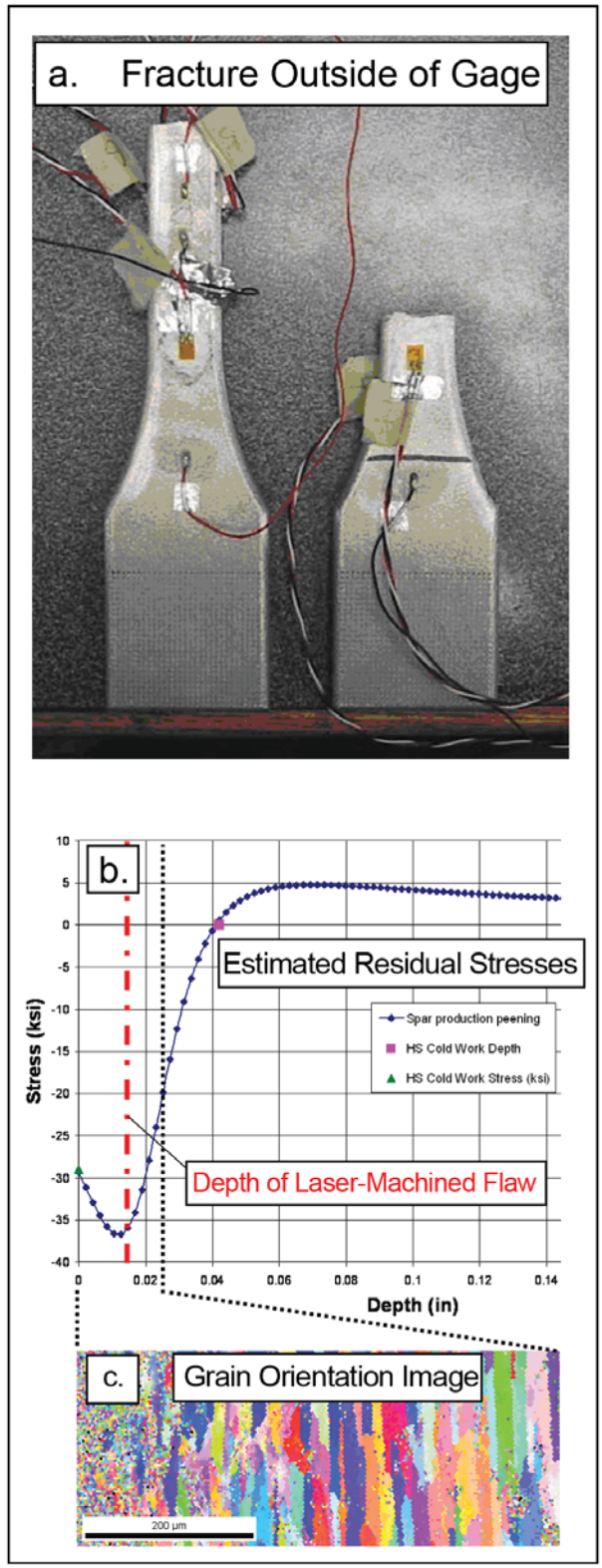


Caption: Results for as-received 7075-T7351 aluminum: a.) Near-threshold FCG data, b.) Fracture surface of specimen subjected to R=0.1, showing the initial laser flaw and fatigue area, and c.) Fracture surface of specimen subjected to R=0.7, showing the initial laser flaw and fatigue area.

The results are summarized in Figure 2 for the as-received 7075-T7351 aluminum specimens tested using R-ratios of 0.1 and 0.7. The fatigue precracking and subsequent load-shedding test procedures were successfully applied to obtain near-threshold FCG region and the arrest threshold stress-intensity factor range for the as-received specimens, Figure 2a. The final shape of the fatigue crack profile at the end of the cyclic loading was nearly semicircular, as shown in Figure 2b and 2c for R = 0.1 and 0.7, respectively. In general, the fatigue crack front progressed concentrically from the initial semicircular laser-machined flaw.

For the shot-peened 7075-T7351 aluminum specimens, crack initiation from the laser-machined flaws was not accomplished during fatigue precracking. Consequently, the shot-peened specimens failed outside the gage section during the fatigue tests, Figure 3a. The depth of the compressive stress region from the shot peening was greater than the depth of the surface flaw and effectively prevented crack initiation, as indicated in Figure 3b. This was further verified using the electron backscatter diffraction (EBSD) technique, which provided a two-dimensional orientation map of the material's microstructure; i.e., the grain orientation and shape, Figure 3c. However, compared to the as-received specimens, the applied load in the shot-peened specimens was more than twice as high. This suggests that crack initiation threshold values in the shot-peened specimens would be a least double that of the as-received specimens.

Results from this study will provide the data that can be used for damage tolerance analyses of rotorcraft and aircraft materials. More details can be found in the Proceedings of the 11th Joint NASA/FAA/DoD Conference on Aging Aircraft, April 21-24, 2008 (http://www.aaproceedings.utcdayton.com/proceedings/2008/techpapers/TP891.pdf). (Continued Airworthiness/Aging Aircraft)



Caption: Results for shot-peened 7075-T7351 aluminum: a.) Fracture outside of gage section, b.) Estimated residual stress profile, showing laser-machined flaw under compression, and c.) EBSD technique showing distortion and orientation of microstructure in the laser-machined flaw region.

Unmanned Aircraft Systems

Initiated in FY 2007, the Unmanned Aircraft System (UAS) research program has yielded preliminary analysis and support for regulatory certification and oversight. The objective of the UAS technology survey is to provide the FAA with a detailed overview of UAS technology status in reference to the existing NAS. Following the regulatory framework, the FAA conducted the UAS technology survey in five (5) technical areas: airframe; propulsion; see and avoid; command, control, and communication; and flight termination. The FAA completed the technology survey and associated regulatory gap analyses in the first four technical areas. Results are documented and are being published in FAA technical reports.

As part of the UAS technology survey initiative, the FAA partnered with the U.S. Air Force Research Laboratory in a joint research effort to conduct flight tests of new see-and-avoid (SAA) technologies. The SAA technology uses electro-optical sensors to provide forward visual queues of other aircraft. In conjunction with other on-board sensors, such as Automatic Dependent Surveillance-Broadcast and Traffic Collision and Avoidance System, sophisticated image analysis and data fusion with thread identification algorithm will command the aircraft flight control systems to perform avoidance maneuvers once the system determines a collision threat is warranted. The first set of the flight testing was completed and results were published in a joint technical report.

In the development of the UAS safety management system, the research initiative implements the FAA Aviation Safety Safety Management System (SMS) Doctrine. The research focuses in two of the SMS essential elements safety risk management and safety assurance. The FAA completed an initial study of scenario driven system-level hazard analyses of UAS operating in the NAS. Based on this study, the FAA began the development of UAS safety risk management concept within the regulatory framework.

As the first step, the FAA completed the initial development of system-level hazard taxonomy for UAS – Hazard Classification and Analysis Systems (HCASs). It took a novel approach from the FAA regulatory perspective, Title 14 Code of Federal Regulation (14 CFR) Subchapters on Aircraft, Airmen, Airspace, Air Traffic and General Operating Rules. The HCAS took a top-down system approach to address potential UAS safety issues in the existing NAS within available regulatory standards. The FAA is in the process of publishing a technical report on the HCAS development and its taxonomies with representative analyses to demonstrate its potentials. (Unmanned Aircraft Systems)

97-3034

Situational Awareness

Common, accurate, and real-time information of aerospace operations, events, crises, obstacles, and weather

Light Emitting Diode Airport Applications

Light emitting diodes (LEDs) have the potential to provide significant energy savings, reduced maintenance, and overall life-cycle cost savings while providing a more reliable visual cue. During the initial implementation of LEDs, it was discovered that caused some system integration issues. An FAA/industry team was formed in August 2007 to address the issue of a common electrical infrastructure for LED lights sources. This infrastructure should include a power distribution system that: maximizes efficiency of the LED fixture, reduces total cost of ownership, and supports an open architecture. This research will continue into FY 2009.

Additional LED implementation issues for use at aerodromes were identified through work done with the ICAO Aerodrome Panel Visual Aids Working Group. Some of these issues were: 1) How will this technology interact if interspersed with standard incandescent lights?, 2) What are the impacts of intensity changes with LEDs?, and 3) What is the impact of the reduced heat signature on the lens of LED fixtures with respect to lens contamination due to environmental conditions? An FAA engineering brief was issued that recommended that: LED and standard incandescent lights not be inner mixed, LED fixtures include electronics to mimic the intensity curve of incandescent lamps, and Arctic (heater) kits be used for all fixtures. (Airport Technology Research - Capacity)

Automated Foreign Object Debris Detection System Evaluation

The presence of foreign objects in the airport environment presents a major hazard to aircraft safety. Foreign object debris (FOD) is any substance, debris, or article found on an airport surface that could potentially cause damage to an aircraft or vehicle. The presence of FOD can be the result of the loss of parts from aircraft, pavement deterioration, wildlife, ice and salt accumulation, or construction debris. Identification of FOD at airports requires frequent inspection of airport surfaces by airport personnel, or random observation by aircraft pilots operating on airport pavement. Usually, these are the only triggers for FOD removal action.

In 2005, the FAA, in cooperation with the University of Illinois, conducted a preliminary short-term evaluation of a radar-based FOD detection system at the John F. Kennedy International Airport. This millimeter-wave radar system demonstrated the capability to detect objects as small as a two-inch bolt on the pavement surface, thereby providing airport personnel with timely FOD alerts and specific information on the location of the object. Although the preliminary research demonstrated successful FOD detection under many operational and environmental conditions it also identified a need to conduct evaluation on a longer-term basis, under varying seasonal conditions.

In 2007, the FAA installed two separate millimeter-wave radar units at the Theodore Francis Green State Airport, in Providence, Rhode Island and collected 12 months of operational data, including winter operations. By March 2008, the results of this study were included in an interim report.

In addition to the radar system, the FAA identified three more FOD detection technologies that demonstrated sufficient maturity. Since each uses a different technology to detect FOD, FAA researchers decided to evaluate each one in a separate study.

In June 2008, the FAA installed another FOD detection technology at Boston Logan International Airport that uses both radar and cameras to detect FOD. The FAA installed 2 more systems, one with a high powered intelligent vision camera system and one mobile system. Evaluation of all three systems will continue into 2009. A comprehensive final report that summarizes the all four FOD detection technologies is expected in 2009. (Airport Technology Research- Safety)

Caption: A bolt on the runway is a typical example of FOD; other examples include metal washers, misplaced tools, and fuel caps.

Improving Pilots' Visual Approaches through Perceptual Training

The visual approach phase of flight 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 model the visual and kinesthetic cues for visual approaches in today's flight simulators. Human factors researchers are investigating the skills pilots need to conduct a visual approach effectively 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, the FAA expects to impact pilot training protocol by reducing initial operating experience 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 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. The FAA expects to find that through discrimination training performance will improve on visual approach tasks. (ATC/Technical Operations Human Factors)

Sensory Deficiencies in the Operation of Unmanned Aircraft Systems

Unmanned aircraft systems (UASs) are those without a pilot onboard. 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.

A technical report was written that summarizes research findings. The report includes 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. Analyses demonstrated that pilots of UAS receive less and fewer types of sensory information compared to manned aircraft pilots. One consequence is an increased difficulty for UAS pilots to recognize and diagnose anomalous flight events that could endanger the safety of the flight. Recommendations include the incorporation of multi-sensory alert and warning systems into UAS control stations.

The research proposed for FY 2009 consists of consolidating the analyses and recommendations from FY 2008 and incorporating those recommendations in the work of several standards working groups. These working groups include the: 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. (Flightdeck/Maintenance/System Integration Human Factors)

Runway Safety Alerting

Runway incursions at U.S. towered airports have been a major area of concern for the NAS for the past couple decades. Runway incursions have continued to occur and incursion rates have remained essentially constant. As consequence, the NTSB recommended the development of a ground movement safety system with direct pilot warning capabilities. To address the recommendation, the FAA initiated three programs: Runway Status Lights (RWSL), Final Approach Runway Occupancy Signals (FAROS), and Low Cost Ground Surveillance (LCGS).

A RWSL system consists of three subsystems: Runway Entrance Lights (RELs), Takeoff Hold Lights (THLs), and Runway Intersection Lights (RILs). RELs are undergoing testing at Dallas/Fort Worth International Airport, TX (DFW) and San Diego International Airport, CA. THLs are undergoing testing at DFW. A RWSL system consisting of RELs and THLs is being installed at Los Angeles International Airport, CA. RILs will be tested at Boston Logan International Airport, MA. The Boston Logan tests will begin during Summer 2009. RELs and THLs will also be installed at BOS.

Flashing of the Precision Approach Path Indicator is the annunciator for FAROS. The first test system was installed at Long Beach, CA. Three induction loop segments along Runway 12/30 constitute the detection subsystem. The PAPI flashes whenever an aircraft or vehicle occupies one of the segments. Enhanced FAROS is undergoing testing at DFW. This version of FAROS will cause the Precision Approach Path Indicator to flash only when an aircraft or vehicle is on a runway and an aircraft on approach to it is within 1.5 nautical miles of the approach threshold. The surveillance source of enhanced FAROS at DFW is the Airport Surface Detection System – Model X (ASDE-X) and Airport Surface Radar (ASR)-9.

LCGS is a low cost and more limited option to ASDE-X as a ground surveillance system at those airports that will not have ASDE-X. Though LCGS does not provide information directly to the cockpit, information is provided to the control tower. Two prototype systems have been installed and tested at Spokane, WA. Additional systems for testing are slated for installation at Long Island, CA; San Jose, CA; Reno, NV; Manchester, NH; and West Palm Beach, FL.

Researchers at FAA, CAASD, and industry made significant progress on flight deck-based and ground-based direct pilot warning solutions for increasing runway safety. CAASD researchers developed a laboratory simulation of a flightdeck-based surface conflict awareness and alerting capability that is an addition to existing CDTI displays. The capability improves flight crew awareness of airport surface traffic and provides alerting of potential surface conflict situations. The capability is applicable to all airports, including non-towered ones. A key enabler of this capability is the use of ADS-B to "see" surface aircraft on cockpit displays. The CAASD research results were a key input to an associated draft RTCA standard and have been transitioned to avionics equipment manufacturers that are now developing prototypes for field evaluation in 2010.

CAASD also completed work in support of a RWSL ground-based direct warning capability. As a continuation of prior year research, CAASD conducted human-in-the-loop evaluations of three possible lighting configurations to be used as the RWSL's Final Approach Runway Occupancy Signal that provides a visual signal to flight crews on final approach that it is unsafe to land due to conflicting aircraft on the arrival runway. The lighting configurations were PAPI lights, touchdown zone (TDZ) lights, and threshold lights. The PAPI lights were modified to flash, the TDZ lights were modified to present a sequenced flashing of red and white, and the threshold lights were modified to present a red and white wig-wag flashing pattern. Each of the configurations still provided their original guidance information to the flight crews while also providing the arrival warning signal. CAASD's 2008 and prior year research demonstrated that a RSWL system would be highly effective. RSWL has been approved for implementation. (CAASD)

Caption: CDTI Display with Depiction of Surface Awareness and Alerting Capability.

Terrain Awareness and Warning System Feasibility for Helicopter Operations

Due to advances in terrain awareness and warning system (TAWS) technology and increases in rotorcraft controlled flight into terrain 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 aircraft be equipped with TAWS; the TAWS regulation be extended to turbine-powered rotorcraft certificated for six or more passenger seats; and 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 research being performed by the University of North Dakota and for document preparation of Minimum Aviation System Performance Specifications by RTCA Special Committee 212 (SC-212). Additionally, scenarios and protocols were developed for data collection on pilot response to terrain alerts and warnings to be conducted during simulator trials run with the University. Minimum Operational Performance Standards for helicopter terrain awareness and warning systems were completed by RTCA SC-212. Data regarding pilot response to terrain alerts and warnings were collected by CAMI personnel, and the results were provided to SC-212 during preparation of their document. (Flightdeck/Maintenance/System Integration Human Factors)

Quarantine Facilities for Arriving Air Travelers

With the possibility of a worldwide outbreak of a new or emerging disease, public health authorities have revived disease control concepts, such as quarantine which is the segregation of individuals who may have been exposed to an infections disease but who are not yet ill. Quarantine historically has focused on ports of entry, which includes airports. The Centers for Disease Control and Prevention (CDC) has sponsored a series of tabletop exercises at airports that identified the need for facilities on airport property to quarantine several hundred people for days or even weeks. As a result, the CDC proposed a rule in November 2005 that requires airports to identify such facilities as part of their pandemic preparedness. [The National Strategy for Pandemic Preparedness Implementation Strategy, May 2006].

To date, however, there has been no discussion of: what types of facilities are necessary, whether such facilities should be located on airport property, whether other existing facilities could be adapted for this purpose or new facilities could serve multiple uses, and who should pay to provide and maintain these facilities. There is also a need to develop guidelines on how airports can maintain continuity of operations if their employees (maybe up to 30 percent) do not come to work because they are either sick or concerned about coming in contact with sick individuals.

This project developed guidance for airport operators to identify potential quarantine facilities on or off their airports and for continuity of airport operations. The guidance has been developed based on factors, such as: 1) physical needs of individuals to be quarantined (e.g., beds, sanitation, security, food); 2) non-airport resources available to provide basic necessities (e.g., Red Cross); 3) structural

requirements for such facilities (e.g., square footage, climate control, plumbing); 4) transportation from aircraft to facility; 5) potential existing facilities at airports or in community, including those identified in other plans (e.g., hurricane shelters, family assistance sites); 6) potential for multiple use for new facilities; 7) operational and financial impacts of identifying on-airport facilities; and 8) planning guidelines for expected maximum number of individuals to be quarantined. (Airport Cooperative Research – Safety)

Assessment of Weather-Related Training Aids

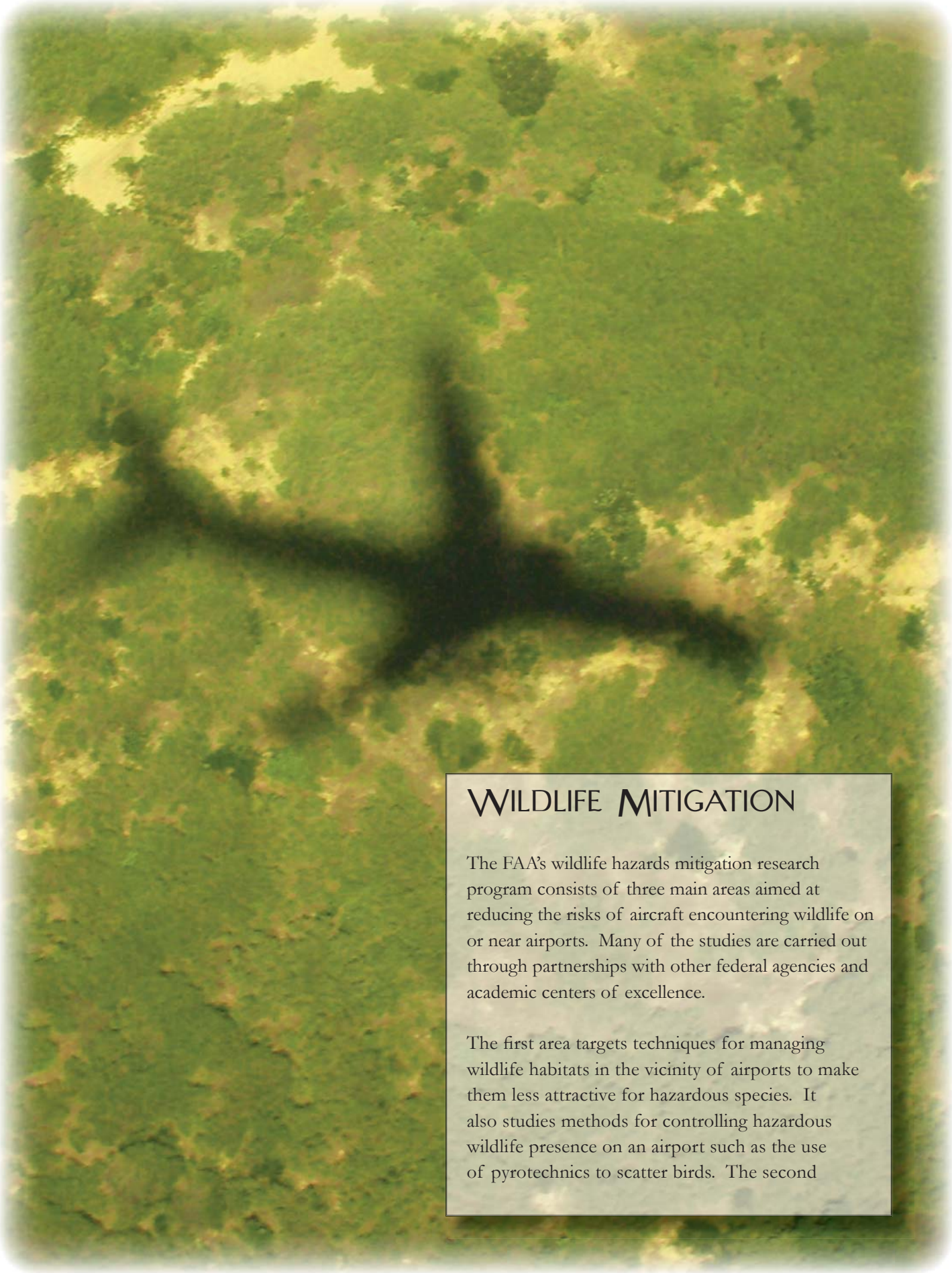
Adverse weather continues to be one of the leading causes of general aviation pilot fatalities in the United States. However, the actual effectiveness of weather training programs is rarely evaluated scientifically. CAMI investigators reviewed two well-known weather training programs to assess their impact on weather knowledge and in simulo flight behavior for 50 GA pilot volunteers.

To obtain a baseline estimate of pilot weather knowledge, CAMI first developed a computerized knowledge pretest based on weather questions. Pilots were then exposed to either one of two weather training videos (the experimental groups) or to a non-weather related video (the control group). Their weather knowledge was then retested with an alternate, matched-difficulty form of the knowledge test, to measure effect of the training products. Repeated measures analysis of variance for posttest-pretest score gains yielded a non-significant pF = .734. This implies that, while there was a slight average knowledge gain associated with the training products (about 2.5 percent), the effect was not large enough to be statistically reliable. In practical terms, this simply means that weather is a complex subject to master, and there is no easy solution to adequate weather training.

Additionally, the data allowed estimation of pilot weather knowledge retention. Comparing these average weather knowledge scores ((pre + post)/2 = 64.3 percent) to official FAA test scores (82.6 percent for these questions, weighted for instrument rating), produced a group wise "weather knowledge forgetting quotient" estimate of about 22 percent over the time since pilots had taken their original tests [(82.6-64.3)/82.6 = 22 percent]. This has implications for both weather training and assessment. Namely, both could be modified to increase pilots' retention of knowledge.

Pilots next engaged in a simulated flight through weather sufficiently challenging to elicit response variation ranging from diversions to alternate airports, to full flight completion. Pre-flight and flight behaviors were measured, including length and types of preflight weather briefing, number of in-flight weather updates requested, total flight time, penetration distance into the weather, terrain clearance, and cloud clearance. Briefly, the two experimental groups were significantly more hesitant to take off than the controls (pX2 = .034). Controls also displayed greater flight duration and, consequently, lower minimum-final-distance-to-destination (Kruskal-Wallis pKW = .007, .005 respectively). However, there were no significant net group differences on overall flight safety as measured by terrain clearance and cloud clearance. Again, this simply implies that there is no easy solution to adequate weather training. It takes more than a 2-hour video to change pilots' knowledge and behavior significantly.

Finally, weather knowledge and flight behavior were again assessed after an elapsed time interval of approximately three months, to test retention of training. That analysis is pending. Final reports will be provided in FY 2009. (Flightdeck/ Maintenance/ System Integration Human Factors)



Wildlife Mitigation

The FAA's wildlife hazards mitigation research program consists of three main areas aimed at reducing the risks of aircraft encountering wildlife on or near airports. Many of the studies are carried out through partnerships with other federal agencies and academic centers of excellence.

The first area targets techniques for managing wildlife habitats in the vicinity of airports to make them less attractive for hazardous species. It also studies methods for controlling hazardous wildlife presence on an airport such as the use of pyrotechnics to scatter birds. The second

area is designed to understand the capabilities of commercial avian detection radar systems to determine their applicability at U.S. civil airports. The projects in this area assess the capabilities of the radars to detect and track birds in complex airport environments. Work is also conducted on developing effective management and distribution of post-processed radar data for end-user applications. The third area collects and disseminates strike information through the FAA's National Wildlife Mitigation website. The website provides extensive information on bird strikes as a well as an online strike database and tools for reporting a strike. Data management, validation, and posting are provided under agreements with the U.S. Department of Agriculture (USDA) and Embry Riddle University. The Smithsonian Institution Feather ID Lab provides identification of bird strike remains for the FAA. In all three areas, the focus is on obtaining accurate and timely information that will lead to the effective management and reduced risks of severe and potentially catastrophic wildlife-aircraft strikes.

FAA expanded its interagency agreement with USDA to characterize bird use of storm water detention basins on airports in the Southwest region of the United States. A study was completed of alternative varieties of vegetation to identify bird foraging preferences and ultimately make airport vegetation less attractive to birds. Another study was initiated to use satellite transmitters to track the movements and habits of resident geese populations in metropolitan environments near major airports. Results from these studies provide airport wildlife biologists, tasked with controlling hazardous wildlife populations and managing habitats on the airport, with vital information regarding hazardous species behavior that poses risks to operating aircraft.

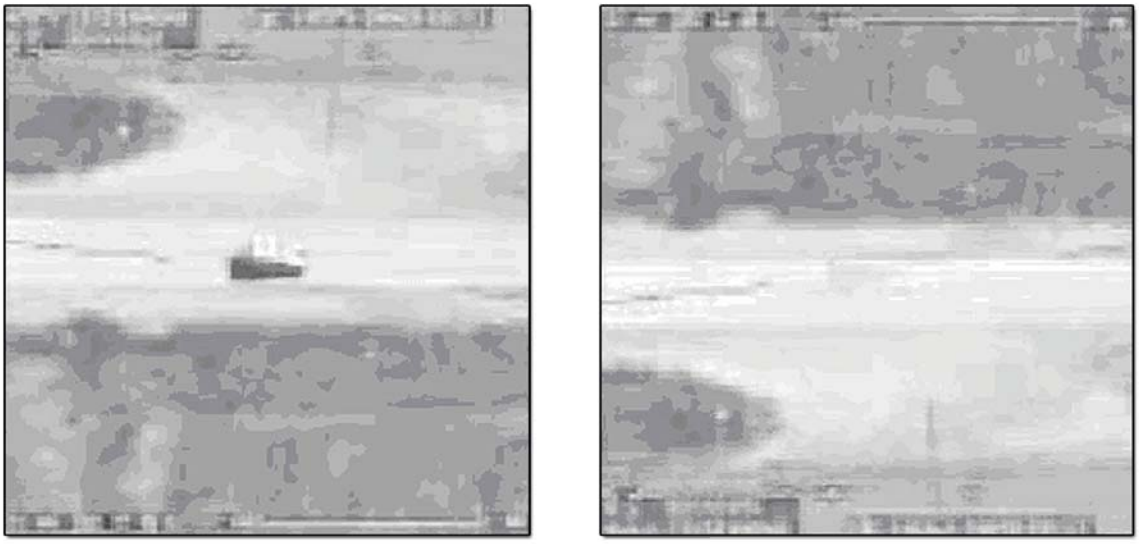
In 2006, the FAA established several cooperative agreements with key universities, agencies, and airports to develop a National Wildlife Hazard Data Network. The initial vision was to develop a national network of radar systems that could provide a near real-time view of hazardous bird activity across the country. The end product would be like a national weather map. While that long-term objective is still viable, recent lessons learned and advances in technology have shifted the approach from a national advisory system to capability validation and assessments to determine how particular systems can best be used at airports. Major partners in this study are the U.S. Air Force, USDA, University of Illinois Urbana-Champaign, Embry Riddle Aeronautical University, and several commercial airports, including Seattle-Tacoma, John F. Kennedy (JFK) International, Chicago O'Hare, and Dallas/Fort Worth (DFW) International as well as avian detection radar vendors. The FAA also serves as a participating partner in a complimentary effort being conducted by the U.S. Navy.

Field studies have continued. A radar system calibration exercise was conducted using remote control helicopter and tethered balloons at Seattle Tacoma International airport to verify target acquisition and tuning. A radar system was installed and is operational at Chicago O'Hare International Airport to determine the best location on the airport to accomplish the objectives of this effort. Additional deployments at Dallas/Fort Worth and John F. Kennedy International Airports were initiated this fiscal year. These field studies will provide the basis for developing performance specifications and use protocols for avian radar on U.S. civil airports. Ultimately, radar is envisioned to be an effective tool for identifying and tracking hazardous species' activity on and near airports. The information can then be used to manage attractive habitat features as well as control resident populations of those species. (Airport Technology Research - Capacity)

Vision Model to Predict Target Detection and Recognition

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 to: 1) 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). For example, contrast thresholds ranged from as little as 2 percent for the largest targets to over 40 percent for the smallest.

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 unmanned aerial vehicles viewing systems and help to address the UAS "see and avoid" problem. (ATC/Technical Operations Human Factors)



Caption: The Spatial Standard Observer (SSO) provides a tool that allows measurement of the visibility of an element, or visual discriminability of two elements. The SSO was applied to these two images of targets viewed from a UAS. The left image contains a target calculated to have a visibility of 4.25 just noticeable difference (JND); the right image contains a similar target that has been reduced in contrast to have a visibility of 1 JND.

Vision Model to Predict Target Detection and Unmanned Aerial System Ground Observer Requirements

The use of unmanned aerial systems (UAS) has been proposed for many civil and military applications within the NAS. For UASs to operate within the NAS, flights must comply with CFR 91.113, which outlines the "see and avoid" responsibilities for aircraft operators. One way to meet the requirements proposed by UAS operators is to employ ground observers to monitor traffic, assess collision probability, and provide operators with timely collision avoidance information. There is little data, however, on how well UAS operators can perform the tasks asked of them.

The goals of this 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 unmanned aerial vehicles 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.

Data were collected at a test site in Oregon to work out details and logistics of data collection. Image data have been collected at detection threshold and 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 NAS. (ATC/Technical Operations Human Factors)

Application of Sequential Decision-making to Traffic Flow Management

Convective weather is often a main contributor to en route airspace congestion, system-wide delays, and disruption in the NAS. Present-day methods for managing congestion are mostly manual, based on uncertain forecasts of weather and traffic demand, and often involve rerouting or delaying entire flows of aircraft. CAASD developed a sequential decision-making simulation capability, in which traffic and weather forecast prediction uncertainty is quantified and used to develop efficient congestion resolution actions. It is based on Monte Carlo simulation of traffic and weather outcomes from a specific forecast. Candidate sequential decision strategies are evaluated against a range of outcomes to gain insight into the cost implications of alternate courses of action. Traffic management decisions can be improved by evaluating the estimated distribution of delay cost and other metrics across the Monte Carlo outcomes, and resolution actions are targeted at specific flights, rather than flows.

To understand the effects of weather forecast accuracy on traffic flow management (TFM) decision making, a weather-induced airspace congestion scenario was explored using the simulation. The effect of three different levels of weather forecast uncertainty was tested. More aggressive congestion resolution strategies were found to be required at higher levels of forecast uncertainty, resulting in more flight delays, higher variability in outcomes, and degradation in NAS user schedule integrity. This is an example of how a trade-off between the costs of improved weather forecasting could be evaluated against the benefits of improved TFM decision making.

The simulation has several useful applications. First, assuming computational power continues to increase, it represents a prototype of a real-time congestion resolution decision-support system. Second, it can be used to study the best decision-making strategies found in the simulation, and from them to develop heuristics for near-term congestion resolution tools and procedures. By analyzing a matrix of interesting congestion problems, rules for effective congestion resolution actions and timing can be derived. Third, the simulation is useful for other cost-benefit analyses similar to the weather forecasting example above. It allows study of the quantitative relationship between new NAS capabilities which improve traffic predictability and the effectiveness of TFM decision making. Thus, the simulation is a platform for evaluating the some of the core challenges of achieving intelligent TFM as part of the NextGen concept. (CAASD)

Weather in the Cockpit Baseline and Assessment

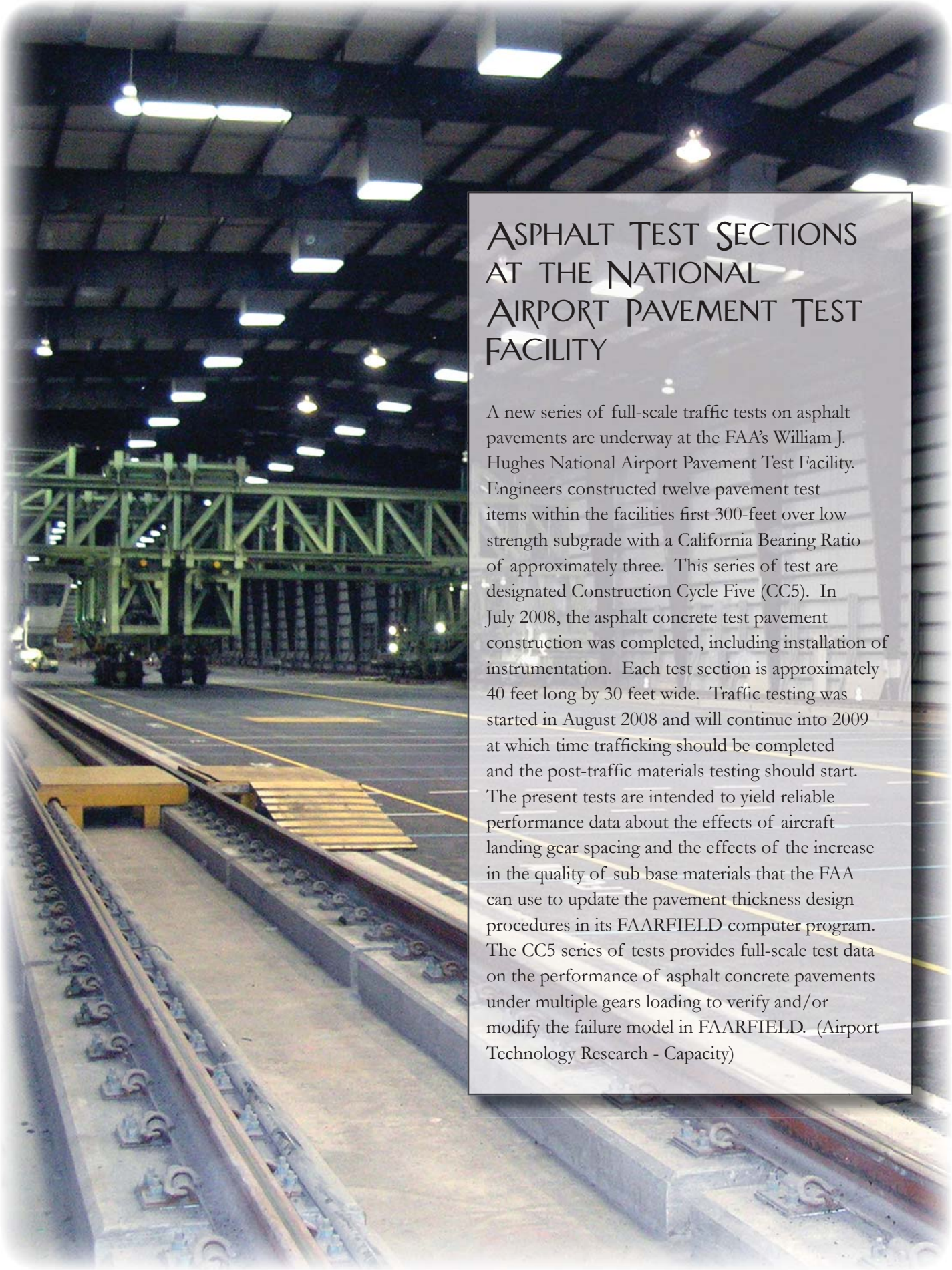
Adverse weather is both a challenge for safe flight operations and a significant limiting factor for airspace capacity. In air transport operations, numerous takeoff and landing accidents have followed encounters with convective weather and winter precipitation. Predicting and avoiding weather and determining when conditions have deteriorated sufficiently to increase risk requires a great deal of attention from air transport pilots and airline operation centers. The Joint Program and Development Office has articulated a vision for 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 resolve challenging flight conditions collaboratively.

To support this transition, CAMI: assembled information on 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; documented the maturity and use of these products; and identified gaps between product capabilities and information needs. In addition, CAMI is identifying key requirements for integration or connection between cockpit and air traffic needs and products.

Data were extracted from a number of sources (e.g., 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 priorities 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. Results were largely as expected, with visibility and ceiling data being ranked highly for initial and terminal phases of flight but with icing and convective-activity information data being ranked more highly for cruise. The data could be used to prioritize the presentation of cockpit weather information by phase of flight. An assessment of weather information use in Airline Operations Centers will continue into next year. (Weather Program)

System Knowledge

A thorough understanding of how the aerospace system operates, the impact of change on system performance and risk, and how the system impacts the nation



Asphalt Test Sections at the National Airport Pavement Test Facility

A new series of full-scale traffic tests on asphalt pavements are underway at the FAA's William J. Hughes National Airport Pavement Test Facility. Engineers constructed twelve pavement test items within the facilities first 300-feet over low strength subgrade with a California Bearing Ratio of approximately three. This series of test are designated Construction Cycle Five (CC5). In July 2008, the asphalt concrete test pavement construction was completed, including installation of instrumentation. Each test section is approximately 40 feet long by 30 feet wide. Traffic testing was started in August 2008 and will continue into 2009 at which time trafficking should be completed and the post-traffic materials testing should start. The present tests are intended to yield reliable performance data about the effects of aircraft landing gear spacing and the effects of the increase in the quality of sub base materials that the FAA can use to update the pavement thickness design procedures in its FAARFIELD computer program. The CC5 series of tests provides full-scale test data on the performance of asphalt concrete pavements under multiple gears loading to verify and/or modify the failure model in FAARFIELD. (Airport Technology Research - Capacity)

Pilot, Designee, and Inspector Perceptions of FAA Services

Caption: After inspection, general aviation pilot will be surveyed on satisfaction with FAA services.

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 of 1993 (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 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 (DPEs) and the practical exam. The 2007 survey was distributed to 5,026 pilots from July 2007 to January 2008. Responses from 1,475 pilots met the criteria for inclusion for a 29 percent response rate. A valid response included respondents who had recently been certificated by a DPE and had not failed a previous practical 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 (97.8 percent). The majority of pilots indicated that the examiner who conducted their practical was prepared and organized to a considerable or great extent (96.8 percent). When asked about events evaluated during their exam, 95 percent said they were asked about weather information, and 97 percent were asked about basic Visual Flight Rules weather minimums. Less than 3 percent of those pilots were asked to repeat either subject area during their examination. In response to items on take-offs and landings, nearly one-third of the pilots said that they did not demonstrate crosswind takeoffs and/or landings; however, 80 percent of those pilots were orally evaluated on the maneuvers. The survey results will be used by flight standards to improve GA safety.

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 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. The analysis included only those respondents who had served as an AME for at least 12 months and conducted an exam for at least one airman during that time (n = 1226). Of the AMEs who met the criteria for inclusion, 76 percent completed an online survey. The results indicate that more than 89 percent were satisfied or very satisfied with the Aerospace Medical Education Division, the Aerospace Medical Certification Division, and the Regional Flight Surgeons. In contrast, fewer AMEs (53 percent) reported being satisfied to a considerable or great extent with the Aerospace Medical Certification (AMC) Internet Subsystem.

Approximately 45 percent of AMEs indicated the Office of Aerospace Medicine (OAM) Website was useful to a considerable or great extent. Overall, domestic, non-military AMEs reported being satisfied with the personnel who provide certification services, but fewer were satisfied with the technological tools (e.g., AMC Internet Subsystem) used for medical certification applications. Specific areas in need of improvement were identified by AMEs – including the standards and guidelines for deferrals, AME training, digital ECG system, AMC Internet Subsystem, and the FAA's OAM website. The survey results will be used by senior managers to: 1) evaluate the degree of customer satisfaction with aerospace medical certification services, 2) identify areas in which improvements in service delivery can be made, and 3) assess change in customer satisfaction as a result of those improvements. (Flightdeck/Maintenance/System Integration Human Factors)

Airport Economic Impact Methods and Models

The role of local airports in regional and state economies has substantially changed in the past two decades and continues to evolve. Airport operators and managers conduct economic impact studies to demonstrate the significance of their airport as a means to persuade policy makers to protect airports against adjacent incompatible uses and as rationale to pursue projects and business lines that would add vitality to regional interests.

Air cargo has the fastest growth rate of any freight mode and has gained economic importance with the growth of national and global markets and supply chains for manufactured goods. General aviation airports that focus on traditional general aviation uses and specialty segments, such as air cargo, corporate jets, or aircraft maintenance, have also emerged. Passenger air travel has taken on increased importance for education, research and development, technology, and tourism clusters. The economic role of larger airports has also changed with the growth of international gateways and shifts in passenger and freight hubs.

Increasingly, these various factors are being addressed by local airport economic impact studies, using new tools and methods for economic impact analysis. Many of the newer studies have moved far beyond the traditional method that were promulgated 15 years ago, which focused on applying multipliers to airport jobs and visitor spending (e.g., 1992 FAA document: Estimating the Regional Economic Significance of Airports.). New guidance might be desirable in the future, and a first step would be to have a synthesis study document the new issues and tools that comprise the state of practice today. (Airport Cooperative Research – Capacity)

Pilot Procedures and Practices for Automated Flight Decks

Automation has introduced changes to the nature 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 to improve the performance of crews using automated cockpit systems. Researchers at or under the direction of George Mason University have used a number of approaches to address this question.

The first approach is to understand training needs and then design training and cockpit procedures with automated systems in mind. During FY 2008, information about the design, use, and training of automated systems was obtained through interviews and observations conducted by researchers from George Mason University and Research Integrations, Inc. at several airplane manufacturers, training companies, and airlines. The team with researchers from the University of Central Florida (UCF) completed a document summarizing what is known from the last ten years of research on automation. George Mason and UCF also leveraged their earlier work on conceptually-and exemplar-based training to develop materials for use in training pilots to complete a visual approach. Many accidents/incidents are caused by new pilots failing to understand how to execute this maneuver; it is not clear what method is needed to reduce incidents and improve comprehension. UCF developed materials for their exemplar-based training and George Mason began production of materials for the conceptually-based training. Finally, George Mason completed production of a CD containing background reports on automation training, background material on why conceptual training is useful, and sample conceptual training developed for training automated systems. The CD was circulated to 600 participants of an FAA-sponsored conference on automation to improve the safety of the flying public.

A second approach 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, training research remains relevant as automated systems evolve. This work produced a report, which will be submitted shortly to a journal for publication, describing the strengths and weaknesses of different analysis techniques that can be used to predict learning and training requirements in the future.

A third approach is to help prevent errors by developing tools that can be used in the cockpit. Researchers at Cognitive and Human Factors, Inc. continued to work with NASA to determine the best ways in which to transition from paper to electronic documents on the flight deck. The work suggested that it is not sufficient to represent paper documents in an electronic format that reproduces the "look and feel" of the original paper document. Rather, it is important to examine the ways in which electronic devices and products change interactions in the cockpit and to develop electronic flight bag procedures and training that can encourage best practices and measurably improve crew performance. (Flightdeck/Maintenance/Systems Integration Human Factors)

Caption: Observations of operations from the cockpit jumpseat during normal operations.

Monitoring and the Use of Checklists

Flight crew monitoring and use of checklists are essential defenses against threats and errors. Both the NTSB 12-year study of accidents attributed to crew error and FAA/NASA research reveal that breakdowns in monitoring and execution of checklists have played central roles in many, perhaps most, airline accidents. The FAA and industry require data on how monitoring is performed and how checklists are typically used on the line. They also require data on the factors that impede effective execution of these critical procedures.

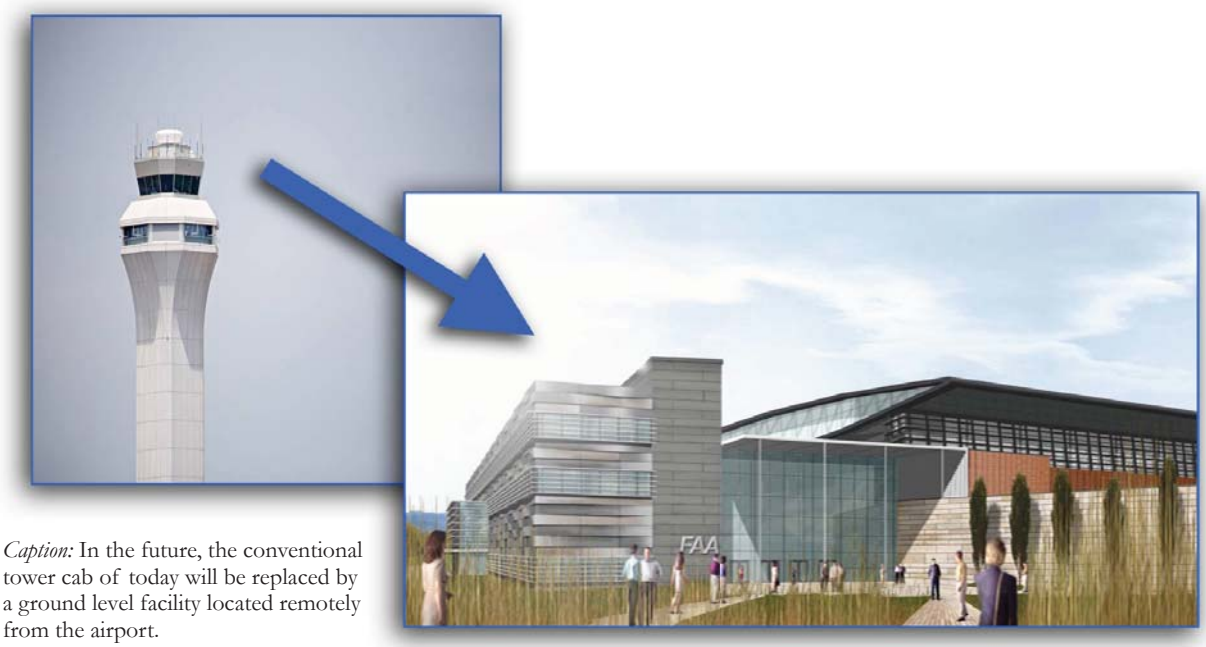
A NASA research team completed 60 jump seat observations of how air carrier crews conduct monitoring and execute checklists in normal operations. These observations were conducted in six aircraft types at three airlines (two in the United States and one in Canada), one which is a major international airline and the other two which are regionals. Preliminary analysis revealed that errors in both monitoring and checklist use are diverse in nature and frequent. Only about 16 percent 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, which include guidelines, training, design of checklists and operating procedures, and organizational policies for reducing crew vulnerability to inadvertent errors of omission, address the FAA goal of improving aviation safety. (Flightdeck/Maintenance/System Integration Human Factors)

NextGen Towers

The air traffic in the United States is expected to increase significantly over the next several decades. Some high-end estimates indicate that by the year 2025 the total passenger enplanements may more than double and total aircraft operations may triple in comparison to the traffic today. In the next 10-15 years, most U.S. tower facilities will reach the end of their useful life. The cost of new tower construction is escalating. The FAA developed the NextGen towers (NTs) operational concept (ConOps) to increase capacity and address the predicted growth in airport tower operations while still addressing the cost prohibitive nature of replacing ATC towers with new towers.

The NT concept reduces the need for physical infrastructure associated with ATC towers and will provide a means to control airport traffic from a ground level location. Two types of NextGen towers are considered: 1) staffed NextGen towers (SNTs) in which air navigation service provider personnel will provide full air traffic management services from a ground-level facility to flights in and out of one or more airports; and 2) automated NextGen towers (ANTs) in which a ground-level facility will be fully automated and a limited number of basic air traffic management (ATM) services (e.g., sequences, clearances and advisories) will be provided without any human participation via synthetic voice and/or data link to the aircraft.

The ConOps develops the NT concept as a first step in the process to determine its operational feasibility. It will be used as a foundation for future analyses (e.g., functional, technical, safety) and development efforts needed to determine its operational feasibility. The FAA approved a research management plan for the first phase of SNT development, Supplemental Operations. The plan ensures the collection of all operational, technical, and economic data needed for an initial investment decision and includes certification of ASDE-X as a critical component in achieving NT. The completed SNT Technology Assessment provides a process to measure and evaluate three critical functional areas (surveillance, displays, and communications) enabling SNT operations and provided recommendations for alternatives. (Operations Concept Validation)



Caption: In the future, the conventional tower cab of today will be replaced by a ground level facility located remotely from the airport.