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The Technical Heart of the FAA

Anne Harlan's Perspective

Dr. Anne Harlan, Director FAA William J. Hughes Technical Center

The William J. Hughes Technical Center (WJHTC) has been called the "Technical Heart of the Federal Aviation Administration." In a recent interview, WJHTC Director Anne Harlan shares what makes the Technical Center unique, and offers her thoughts on why this facility has become critical to the research efforts of the entire aviation community.

Q: What is the mission of the Tech Center?

A: The William J. Hughes Technical Center is the nation's premier aviation research, development, test, and evaluation facility and plays a key role in the Federal Aviation Administration. As a vital part of the Air Traffic Organization (ATO), we see our mission as providing integrated engineering and research services for the development and support of a safe, secure, and efficient global aviation system. Because our job is to look at the closely related issues of how to increase capacity and improve aviation safety, we support just about every FAA organization, particularly the ATO, as we explore new concepts, evaluate new technologies, and develop new procedures or other changes.

I think that one of the Center's key benefits to the aviation community is how we integrate what might appear, at first, to be separate elements. We maintain state-of-the-art laboratories, both in the air (that is, set up in specially equipped aircraft) and on the ground that correspond to just about every piece of equipment now in use or under development in the United States air traffic system. These unique

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facilities allow us to explore the true effects of possible technical changes, whether their purpose is for technology refresh or insertion of totally new concepts into the National Airspace System (NAS). While our experts explore how these changes might impact the system as a whole, we are also looking for any impacts, positive or negative, that these changes could present to the controllers and pilots who work within the system.

Sometimes, if you are totally focused on your own area, the changes you bring about can have consequences you've never intended. By testing a proposed change in a non-operational equivalent system - and relying upon the participation of actual controllers, technicians, and pilots - we learn a great deal about what will work and what won't. We see experimentation, human factors analysis, systems engineering, modeling and simulation, among other forms of test and evaluation to arrive at information that can help the FAA make the best possible decisions.

Although our laboratories support capacity, safety, and security research, this issue of R&D Review focuses on our air traffic management work. The Technical Center, however, is really comprised of several organizations, including the FAA's airport and aircraft safety research and development programs, ATO organizations that provide second level engineering support to help solve real time field problems, superb support personnel who provide a variety of shared services, such as financial and acquisition management, information technology and facilities engineering, as well as the Department of Homeland Security's Transportation Security Laboratory, the Federal Air Marshal Training Facility, the U.S. Coast Guard's Air Station/Group Atlantic City, New Jersey, Air National Guard's 177 Fighter Wing, and the resources of the Atlantic City International Airport.

Q: Where does the Center fit into the FAA's new Air Traffic Organization? Do you anticipate that its research and test functions will change under the new organization?

A: We are part of the Operations Planning Service Unit which is the group focused on the future. The service unit includes all the components necessary for the ATO to make good decisions about how and what to change to meet the needs of our customers and owners. Not only does it include and integrate FAA research, but also includes the business planning organization so we can anticipate how changes in the industry will impact the ATO, and the system engineering organization so changes can be reflected in the NAS architecture.

As far as whether research will change under the new organization, I think it will actually change for the better. With budget declines, it is more important than ever that we and our partners undertake research that is focused and integrated into a total aviation solution that ensures both safety and capacity needs are met within our operational and budget constraints. Integrated management of R&D will provide a mechanism to vet research proposals against the FAA's strategic vision, to ensure development and deployment of approved concepts, and harmonize research efforts of FAA, the Joint Planning and Development office, other government agencies (including NASA), industry, federally funded research and development centers, and academia.

Since the ATO is a new organization, there naturally will be some concern as we transition from the old to the new. I want to emphasize, however, that for the first time, I see the many FAA organizations heading down a common path toward a common goal. If you look at the ATO-wide response to Flight Plan 2005-2009, the document that outlines the entire FAA's immediate direction, you will see that the new organization is already united in its determination to meet the stated objectives for safety, capacity, international leadership, and organizational excellence. All of our priorities map to a single plan, one that identifies expected outcomes and metrics. As a result, I believe, the Center will be able to plan better for its future needs, and

thus ensure that resources remain targeted on aviation's most critical priorities.

Q: How would you describe the Technical Center's core capabilities?

A: We provide a unique environment to develop, test, and integrate new systems and subsystems into the NAS. That means our workforce reflects scientific and engineering disciplines, such as systems engineering, human factors, mathematics, physics, engineering research psychology, computer science - and many others. It's how those disciplines are put together that defines the value of our total capabilities, which I see as applied research, system integration, test and evaluation, and modeling and analysis (with its related high-fidelity, human-in-the-loop simulation).

We also operate and manage state-of-the-art, multi-user laboratories - including those associated with our fleet of aircraft - to answer the questions of tomorrow. While it may sound like we do this all on our own, in reality, we work closely with many members of the FAA, NASA, MITRE, DoD, as well as with the U.S. airline industry and research facilities in other countries.

Q: The Center's research, test, and evaluation focuses on many issues related to air traffic control. These include technical matters such as the engineering and testing of communication/ navigation/surveillance systems, and related aviation simulation; all of these involve investigations of what is known as human factors. What types of laboratory facilities support each of these activities? And what makes them unique?

A: We are fortunate to have some extraordinary integrated simulation and test capabilities. We have the important ability to link laboratories that individually bring particular insights and collectively add up to a unique variety of airspace environments. Through versatile communications networks, these labs and test beds can be further integrated with other laboratories, actual NAS facilities, and many types of aircraft to evaluate a variety of air traffic concepts.

Our extensive data-sharing capabilities allow testing to be conducted on flight simulators - whether "in-house" or at a remote location - that incorporate any weather conditions we want together with just about any combination of existing or experimental communications, navigation, and surveillance systems.

The cornerstone of our air traffic laboratory complex is the NAS Laboratory, which encompasses 108 different air traffic control systems, ranging from the oldest legacy systems still in use anywhere in the country to the newest systems, all within a giant, 150,000 square foot complex. This unique grouping of laboratories supports all stages of research and acquisition - from concept exploration and system development to field implementation.

In these high-fidelity laboratories, researchers can simulate air traffic operations any place in the world on radar displays using computer-generated aircraft in place of real airplanes to solve complex air traffic control problems. The laboratories provide for seamless integration of test beds for research, development, test, and support of operational air traffic control systems and subsystems. In essence, the lab facilities provide:

- A realistic environment for evaluating the engineering of air traffic control infrastructure and subsystem enhancements;
- A common infrastructure for integrating and testing the interoperability of air traffic control subsystems and functions;
- An improved structure for determining actual development and life-cycle support costs of air traffic control functions; and
- Capabilities, equal to any in the world, for use in developing, validating, prototyping, and evaluating aviation engineering solutions.

We also have some other exciting facilities, such as our Tower Integration Laboratory, which helps engineers determine the best ways to "site" new facilities without actually having to build them; the Human Factors Laboratory, which engages in all aspects of user interface and human operator issues; and the En Route Integration and Interoperability Facility, which

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allows us to explore how changes in new technology will work in the en route environment. Our flying laboratories provide a mechanism to test air-to-ground technologies, to evaluate space-based technologies such as the Global Positioning System, or to fly new airport approaches. Other ATO organizations also use our laboratories to replicate a problem experienced in the field so they can quickly develop a software solution.

Q: What do you consider some of aviation's key challenges? How is the Technical Center helping the aviation community meet those challenges?

A: I really believe the aviation industry is facing unprecedented challenges. Passenger demand for air transportation services is increasing so rapidly that the number of travelers could reach 1.1 billion by 2014. We are expecting record growth of unmanned aerial vehicles (UAVs) and smaller, regional and commuter jets, with 549 aircraft being added over the next two years - for an increase of roughly 40 percent. Air cargo is growing even faster. In the last five years, airfreight tonnage has increased by 60 percent, a rate of growth that can only be expected to continue. With all that growth, we should be looking at a healthy industry, but, as you know, we're not. The industry itself is wrestling with issues of hub and spoke vs. point-to-point service; low cost carriers vs. full service; huge upsurges in fuel prices and drops in ticket pricing; and overall, just enormous competition. There are other clouds looming as well.

Manufacturers are under pressure to cut noise and emissions from aircraft. Consumers still have concerns about security and safety of aviation despite the unprecedented safety record of the industry. All that growth is shrinking capacity and increasing delays at some key airports. Innovative new technologies may come to the rescue, but only if they satisfy a financial bottom line. More flexible and efficient air traffic management procedures need to be adopted to make better use of our finite airspace.

The Technical Center's researchers and engineers are working to find solutions to these challenges. Together with our domestic and international partners, we are developing and testing new technologies and procedures that will result in an environmentally friendly but flexible system that can efficiently, safely, and securely handle increased traffic. In short, we are laying the foundation for the airspace system of the future.

Q: What are some of the projects Technical Center engineers are currently working on?

A: At any given time, Center employees have more than 150 active projects underway. Although space is lacking in this article to list all the critical projects we are working on, let me give you just a few examples.

We are currently increasing our cooperative work with NASA Ames to develop new air traffic management technologies, such as the En Route Descent Advisor and the Multi-Center Traffic Management Advisor. To facilitate these collaborative efforts, NASA and the FAA have agreed to share knowledge, resources, laboratories, and technologies. So, we now have co-located FAA personnel at various NASA research facilities including Ames, Langley and Kennedy Space Center to facilitate early FAA involvement in NASA development projects and to help smooth the technology transition between our agencies.

Our human factors specialists are now examining many available and proposed weather products to see how they might be made more useful to air traffic controllers in the terminal environment. They are looking for empirical answers to questions like: What weather information do terminal controllers need? Where and how should this information be presented? And how could this weather information be used operationally? Later, the project will conduct a simulation to measure the operational benefit of the selected products. Researchers will determine what weather information would be helpful to controllers, and then they will provide guidelines for the optimal display and use of this information.

We have also been working on the Alaska Capstone project, which uses technology to overcome a problem that has long plagued Alaskan pilots and air traffic controllers. For years, limited radar coverage posed serious safety implications for pilots flying in that region. Our work with other parts of the ATO and FAA personnel in the Alaskan region demonstrates that, when pilots have access to better flight positioning information along with current weather and traffic alerts, the number of fatalities drops dramatically. We are continuing to work to ensure that these capabilities are extended to virtually all pilots flying in this difficult environment.

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Laboratory Facilities

Providing the Testbeds for the Next Generation Aviation Systems

As the national scientific test bed for the FAA, the Technical Center fulfills an important role by providing numerous specialized simulation and testing facilities that support a vast number of research, development, and acquisition programs. Located on 5,052 acres outside of Atlantic City International Airport, the Technical Center consists of laboratories, test facilities, support facilities, and an airplane hangar housing a fleet of specially instrumented research aircraft.

The Center possesses extraordinary state-of-the-art simulation and test capabilities with the ability to link individual laboratories producing a wide variety of airspace environments. Through versatile wide-area and local data communications networks, these labs and test beds can be integrated with other laboratories, actual National Airspace System (NAS) facilities, and aircraft to evaluate a variety of air traffic concepts. The FAA's extensive data-sharing capabilities allow for testing to be conducted on a real-time basis by incorporating both in-house and remote flight simulators, weather, communications, navigation, and surveillance systems.

The Technical Center's air traffic laboratory complex includes the NAS Laboratory, which encompasses over 100 different air traffic control systems. This laboratory complex supports all stages of research and acquisition from concept exploration and system development to field implementation. In these high-fidelity labs, researchers can simulate air traffic operations any place in the world on radar displays using computer-generated simulated aircraft in place of real airplanes to solve complex air traffic control problems. The labs provide for seamless integration of test beds for research, development, test, and support of operational air traffic control systems and subsystems. Some of the laboratories, include:

Technology Integration Laboratory - provides a simulation, verification, validation, test, and evaluation environment for air traffic management tools and technologies. Here, researchers can evaluate the latest technologies with existing air traffic control systems for non-interference and functional demonstrations, real-time simulations, and training.

En Route Integration Interoperability Facility - provides a complete en route system environment to perform research, development, and integration of new and existing systems. It creates an environment for performing experimentation, prototype evaluation, system-level integration and verification without affecting actual air traffic operations or air route traffic control center (ARTCC) personnel. The facility is available to both government and industry organizations that support the emerging NAS architecture.

RADAR Test Labs - provide a source of live surveillance data to the air traffic laboratories. Coverage from the two terminal radars extends to a maximum range of 60 miles and the en route radar covers up to 250 miles.

Tracking Range - includes both a tracking radar (i.e., Range Instrumentation Radar (RIR)-778) and a Global Positioning System (GPS) based configuration, both of which are used for airborne tracking, data collection, and data analysis. The GPS-based system is portable thus enabling data collection at locations other than the Technical Center. The overall system provides time-correlated space position of test aircraft to a high degree of accuracy. A second generation VHF omni-directional range (VOR) is also maintained for operational use.

Engineering Cockpit Simulator - consists of a transport aircraft cockpit with all instrumentation and flight dynamics driven by a network of high-end graphics workstations. The software can simulate nearly any commercial transport aircraft, using five networked graphics computer

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machines to simulate a given aircraft, including an out-the-window display. Classified as a flight-training device, the simulator uses high-resolution computer-generated images to graphically depict airplane controls and displays that are located on the forward instrument panel.

Next Generation Air/Ground Communications (NEXCOM) Laboratory - provides the capability to test and evaluate state-of-the-art next generation voice and digital multi-mode radios using time division multiple access and carrier sense multiple access technologies.

NAS Inter-facility Communications Laboratory - provides the capability to support users conducting integration and testing on inter-facility communications systems. These test beds include: data multiplexing network; radio communications link (RCL); low density RCL; bandwidth manager network; FAA internet working protocol routed multi-user network; and Eastern Caribbean telecommunications network.

Aviation Weather Facility - provides an integrated central facility for the research, development, and evaluation of aviation weather systems and products, including products of various FAA weather programs and those of other federal laboratories. It brings a capability for rapid prototype development and independent evaluation of air traffic weather systems and products in a distraction-free environment. The facility also supports the research, development, and evaluation of terminal and en-route products and systems.

Wireless Security
Includes the capability to rapidly prototype and evaluate wireless security solutions based on Commercial Off The Shelf (COTS) products. The laboratory is designed for rapid prototyping and is designed to be quickly reconfigured to support multiple wireless architectures. The laboratory has been used to evaluate hardware and software from most of the largest vendors in the wireless network industry in support of the prototyping efforts. Some of the products generated from the use of this laboratory are system's authentication verification, security policy documents, and Security Certification and Authorization Package (SCAP).❑

Technology Transition

FAA and NASA Join Ranks to Improve the National Airspace System

The FAA and NASA both perform research and development in various areas of air traffic management to help manage current air traffic and to prepare to meet future demand with new capacity and safety enhancements. Each agency recognizes that having an early understanding of the other's research efforts could be beneficial to both agencies and to the flying public.

Since 1970, the FAA and NASA have pooled their resources to develop and deploy new technologies into the national airspace system. Early collaborations typically involved research addressing the introduction of new vehicle classes (supersonic transport), sophisticated avionics systems (head-up displays), and complex navigation systems (global positioning system). Today, the research efforts have expanded into the design, development, and evaluation of decision support tools and advanced concepts for air traffic management. Before being integrated into the current national airspace system (NAS), these new technologies must go through a rigorous adaptation, testing, and implementation process.

To facilitate this collaborative process, the FAA's William J. Hughes Technical Center and the NASA Ames Research Center signed a memorandum of agreement (MOA) to share knowledge, resources, laboratories, and technologies. The MOA describes the Technology Transition Program, which is designed to ensure the effective and expeditious transfer of NASA technology to the FAA with the goal of improving efficiency and reducing the time

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A View from the Top

Tower Modeling Ensures Safety

"Because air traffic control tower interior design and layout, site selection and orientation, height determination, and transition of equipment into the tower environment are critical to safety, the FAA developed the Airport Facilities Terminal Integration Laboratory (AFTIL)," explains facility manager William Vaughan. He adds: "This facility has revolutionized the way the FAA plans for and constructs air traffic control towers. The AFTIL allows us to simulate potential tower sites and airport operations in a realistic air traffic control tower, using airfield photographs and aircraft simulations. To date, we have completed over 40 airport tower siting projects. The AFTIL also provides an optimum operational environment for the identification and resolution of transition issues related to the implementation and integration of air traffic control tower systems and equipment. In addition, the AFTIL can serve as an important test bed to study airport capacity concerns such as runway acceptance rates and alternative approach-departure sequencing."

The AFTIL's Cab Simulation Suite contains nine six-foot by eight-foot screens that provide a 360-degree out-the-window display area, a control tower wrap-around console, tower support equipment, and a tower simulation system supporting pseudo-pilot communications. With its panoramic photographs and/or computer generated graphics, the suite can display any airport's existing facilities and even represent any planned airport construction such as hangars, terminals, runways, or taxiways. This system can also create a 3-dimensional airport to evaluate potential tower sites and determine if clear and unobstructed views of the airport surfaces and approach paths are attainable from the various tower control positions. The computer airport model is suitable for depth perception studies and evaluations of various console heights and angles. Air traffic control procedures associated with planned future airfield changes can also be evaluated in this real-time environment, making this a viable test bed to study airport capacity issues such as runway acceptance rates and alternate approach-departure sequencing.

Adacel's MaxSim simulator can support high-level activities and complex traffic flows. The fully configurable flight envelope lets the user specify any desired flight parameters for each aircraft. Data familiar to air traffic controllers defines the characteristics of aircraft that can also include helicopters and tilt-rotor aircraft. Pseudo-pilots can generate an aircraft target by providing simple information (i.e., call sign). It is easy to program any traffic pattern or instrument approach procedure into the simulator's scenario generator as an air route. These air routes may be assigned to an aircraft during scenario creation or during run time. Traffic patterns can be configured to comply with all flight rules and airspace specific parameters.

The visual system's software program also allows for a variety of weather related special effects, including reduced visibility for rain, fog, snow, dusk, dawn, and night-time operations. The density of the fog can be dynamically changed. The visibility is adjustable from less than one statute mile to unlimited. The sun and moon can also be placed in the scene at the accurate position in the sky based on latitude/longitude and time of day and year.

This highly versatile simulator allows for the recreation of all standard runway operations. FAA personnel model all airport terrain from real world data such as airport maps and charts, a process that can take

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Our researchers are also actively developing cutting edge technologies that will improve aviation system efficiency and reduce related costs. As part of this work, we compare the levels of risk posed by alternative technologies, and we offer mitigation approaches, if needed, to help the FAA effectively field the best, most promising solutions. You will read more about some of this innovative work in this newsletter. As you will see, we take great pride in bringing the best possible products and services to our customers as we work with the aviation community to ensure a strong future for aviation.

Q: Where do you see the Technical Center in the next five years?

A: I believe that as the FAA works with the aviation community to create the air transportation system of the future, the Technical Center will become increasingly important as a research, development, test, and evaluation center for the entire aviation community. It has the potential to be the focal point for a joining together of government agencies, academia, and private sector to work collaboratively on the tremendous challenges before us. There is no question that we have the expertise and the facilities here to do just that. By linking our ideas and capabilities with those of others, we can truly test and evaluate the best in creative and innovative ideas. Our ability to conduct real-time evaluation as well as high-fidelity simulations of new procedures and equipment is key.

Whether it be a human-in-the-loop simulation that helps to improve the interface between operators and systems, a virtual reality look or computer generated airport environment that helps to site new equipment, a model that determines the amount of capacity a new runway or new technology might add at an airport, or an experiment that documents how controllers actually deal with various workloads, any technique we apply here is highly cost effective. All of our methodologies provide data needed by the FAA to make the right near-term and longer-term decisions. As we become more focused on the budget challenges before us in the aviation industry, I believe more use will be made of our facilities and expertise.

I also believe that our work with international partners will increase in the future. Aviation is a global enterprise and, therefore, research and development is not an activity that can be managed in isolation by one organization or even by one country. We already have a long tradition of working cooperatively with our international partners. Currently, we join together in exchanges of scientific and technical personnel as well as information, by performing joint analyses, and by coordinating our respective research and development programs and projects. Our facilities and employees are highly regarded international resources, and as we work to harmonize global standards and procedures, we will play an even stronger role in international cooperation.

Q: In 2008, the Technical Center will celebrate its 50th birthday. In your opinion, how has the Center adapted over the years to better support the FAA and the aviation community?

A: The FAA also turns 50 in 2008, and the Technical Center has grown along with the Agency, helping to support its regulatory and safety mission and helping to achieve its goals. Our initial mission was "to develop, modify, test, and evaluate systems, procedures, facilities and devices to meet the needs for safe and efficient air traffic control of all civil and military aviation." In 1958, most of the scientists and engineers worked in temporary buildings dating from World War II. They lacked new equipment, making it difficult for them to undertake a wide variety of studies. Our mission remains very close to that of 1958, but we have seen real progress in the quality of our facilities, the expertise of our people, and the value of our contribution to aviation.

Today's Center houses the world's best aviation laboratory facilities and attracts researchers from around the world. In fact, measured by the quality of the research and integrated engineering support, the expertise of our scientists, specialists, and staff, and the impact of our work on the aviation community, our progress has been tremendous. We are making an enormous difference acting upon our national determination to keep aviation safe, secure, and efficient. And we are confident our valuable contributions to global aviation will continue into the future.❑

For more information on the William J. Hughes Technical Center, please see www..tc.faa.gov

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up to eight weeks depending on airport complexity. They depict critical airport features such as runways, taxiways, terminals, and airport obstructions for instrument approach procedure development, as well as planned new runway and taxiway construction, new terminal buildings, hangars, and concourses. The airport operating areas can be modeled to the accuracy of the dataset and will include any "humps" and "dips" in the airport's runways, taxiways, and ramps.

"In the near future, the FAA hopes to create a standard Airport Traffic Control Tower siting process that can be tailored to any size airport. This will streamline the siting process, saving us time and money; but to develop this process we need to capture and validate highly accurate airport data, keep it current, and maintain its configuration," says Vaughan. The FAA recently signed a reimbursable agreement with the state of Florida to use Tampa International Airport to test a new data collection technology, called photogrammetry. This technique measures objects, in either two or three dimensions, based on photographs or electronic images captured from such sources as video, digital camera, or radiation sensors including scanners. Once they refine airport layout and design modeling techniques, FAA researchers and engineers hope to release up to 20 airport models in 2006. These models, as well as the AFTIL simulations, will help the FAA find and resolve potential problems before tower construction begins. The information gathered from these simulations is being used to develop a new FAA siting process and standards. "New towers cost millions of dollars," explains Vaughan, "and our work is helping to ensure that any new tower enhances airport and air traffic safety and that our investment in new towers is protected well into the future."❑

For additional information on the AFTIL, please see http://aftil.tc.faa.gov/INDEX.HTM or contact William Vaughan at william.vaughan@faa.gov.

Creating the Network in the Sky

Airborne Internet/Collaborative Information Environment

All over the world, people now own the equipment and have the skills to profit from this age of "real-time" communications. But when we travel, most of us feel cut off from the rich information flow we take for granted at home or in our offices. A consortium formed by the Airborne Internet Collaboration Group would like to change all of that and bring full information connectivity to people in transit. (See *R&D Review*, Winter 2003, pp. 23-24.)

"Connectivity" is the word of the day. Electronic digital circuits, especially computer networks, are being introduced into a huge variety of applications to increase the speed and breadth of universally shared information. High-speed broadband networks are being created every day to connect people who want more than just having information available on their desktops.

An enhanced Airborne Internet/Collaborative Information Environment (AI/CIE) would extend the benefits of computer network theory and principles into the transportation realm. When people travel, they generally experience "connectivity down time" and feel detached from the information that their usual network provides.

Wireless networks are rapidly emerging to help fill this void. People who travel with laptops or personal digital assistants now can connect briefly to their familiar networks from business establishments like cafes or bookstores. Some airport terminals also are hosting wireless connectivity for travelers with idle time before and between flights.

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Having access to more real-time information is also important to pilots and controllers. The use of a new general purpose, multi-application data channel for flight deck functions would make it possible to use older flight deck functionalities in combination with newer technologies, once all systems were appropriately digitized. A richer level of information could be transferred to, from, and between aircraft. Safety benefits and cost savings would result.

Technology that allows a user to move from one network to another without losing connectivity has been developed and matured to the point that it is ready to be applied to aviation. The invention and growth of personalized information services, for example XML services, is changing the landscape of the worldwide web as we know it today.

The advent of these new services has led to a complete shift in how information systems are integrated. With these new technologies, information can now be published as soon as available, regardless of the platform, operating system, or the device of either the information source or the end user. Currently in aviation, very little information can be updated digitally during flight. Through XML aviation services, aircraft operators could receive automatic updates of weather, landing conditions at the destination airport, turbulence ahead, and other information.

The flight deck avionics consolidation made possible by an Airborne Internet/Collaborative Information Environment would help industry reduce their costs and increase profitability. As operator of the national airspace system, the FAA could also benefit from the cost savings and safety improvements when today's analog flight functions are made usable in combination through a digital delivery system. And, if it could provide enough bandwidth, the new channel might even allow airlines to bring network connectivity safely and affordably to passengers. With excess available bandwidth, the airlines could possibly sell network bandwidth capability to the local operators of smaller aircraft who need it.

The Airborne Internet/ Collaborative Information Environment could be particularly beneficial to new, smaller jet aircraft. These small jets will cost less than half of that of their predecessors, use 3,000-foot runways, and operate at less than $1 per mile. They are currently the business focus of numerous air taxi operators who will use them in small rural airports to transport people quickly and efficiently without the need to use the large hub airports.

The customers who use these air taxi services will also want to remain connected to their networks as they travel. In addition to satisfying the needs of their passengers, the Airborne Internet/Collaborative Information Environment might offer air taxi service operators a better means to monitor the maintenance of their aircraft. In fact, these service providers might be the earliest adopters of the airborne Internet.

The high tech industry is leading the way in establishing industry standards through its own consortia, rather than through standards setting bodies, to bring products more quickly to market. Use of new industrial processes and standards could help to streamline the aviation community's ability to deploy new technologies. Many societal trends have emerged to make today the perfect time to create the Airborne Internet/

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Domestic RVSM

Preparing for the Future ATM System

On September 27, 2004, Secretary of Transportation Norman Y. Mineta announced several new agreements between the United States, Canadian, and Mexican civil aviation authorities that will result in a seamless satellite navigation system, more direct aircraft routing procedures, and greater airspace capacity and flexibility. "The economies of our three great nations rely on transportation to connect products to consumers, businesses to their customers and tourists to their destinations," said Secretary Mineta. "We must make flying throughout North America as seamless as possible if we are to truly reap the rewards of the expanding global economy."

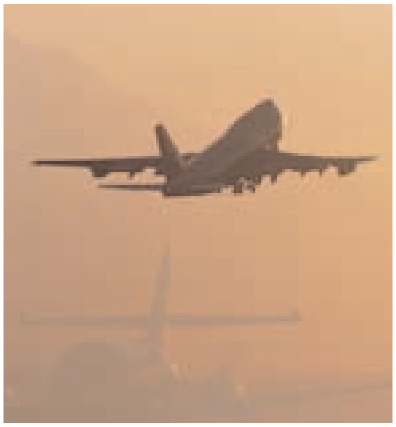
Mineta announced a new agreement with the three North American countries to implement a common Reduced Vertical Separation Minimum (RVSM) for North American airspace starting January 20, 2005. RVSM is the reduction in vertical separation for properly equipped aircraft flying between 29,000 and 41,000 feet. Most importantly, he noted, RVSM increases airspace capacity at high altitudes, providing greater flexibility for air traffic controllers and pilots, reducing delays and saving fuel.

This "marks a big step toward a seamless aviation system for North America," said FAA Administrator Marion C. Blakey, who represents the Department in the North American Aviation Trilateral (NAAT) and served as the U.S. negotiator for the initiative. NAAT members agreed to work together to implement Required Navigation Performance/Area Navigation (RNP/R-NAV) in North America. RNP/R- NAV uses improved aircraft navigational technologies to allow pilots to select more direct routes, saving on flight times and fuel costs. These reductions can also provide environmental benefits.

Background

On October 22, 2003, the FAA issued a rule that will implement Reduced Vertical Separation Minimum (RVSM) on January 20, 2005. Domestic RVSM will increase capacity and operating efficiency at high altitudes by reducing the minimum vertical separation between aircraft from the current 2,000 feet to 1,000 feet for all aircraft flying between 29,000 feet and 41,000 feet. Reducing the vertical separation to 1,000 feet will add six new cruise altitudes, significantly increasing the routes and altitudes available.

RVSM is a safe and cost-effective method of increasing airspace capacity, reducing enroute traffic conflicts, and optimizing the use of customer-preferred flight profiles for domestic and international operations. Reducing the separation between aircraft virtually doubles the available airspace where 90 percent of airlines and business jets operate. This will reduce congestion and provide for future traffic growth. Significant fuel savings and associated reduction in greenhouse gases will also be realized by allowing aircraft to climb more quickly to higher cruising altitudes, where fuel consumption is lower. The estimated fuel savings of $5.3 billion through 2016 far exceed the estimated cost of over $800 million



to modify aircraft to meet RVSM standards.

The benefits from RVSM go beyond time and fuel efficiency. RVSM offers greater flexibility for air traffic controllers and reduces their workload. This flexibility is particularly useful when controllers must re-route flights around bad weather. More available routes and altitudes mean controllers will have more options to separate aircraft on intersecting routes.

Domestic RVSM is projected to accrue the following benefits:

For operators

- Fuel Savings Benefits 2005-2016:
  - $5.3 billion
  - 6/1 benefit/cost ratio
  - $393 million first year savings (with 2.0% annual increase)
  - Greater availability of more fuel-efficient altitudes
  - Greater availability of most fuel-efficient routes

For Air Traffic NAS Operations

- Air traffic control flexibility (e.g., routing aircraft around storm systems)

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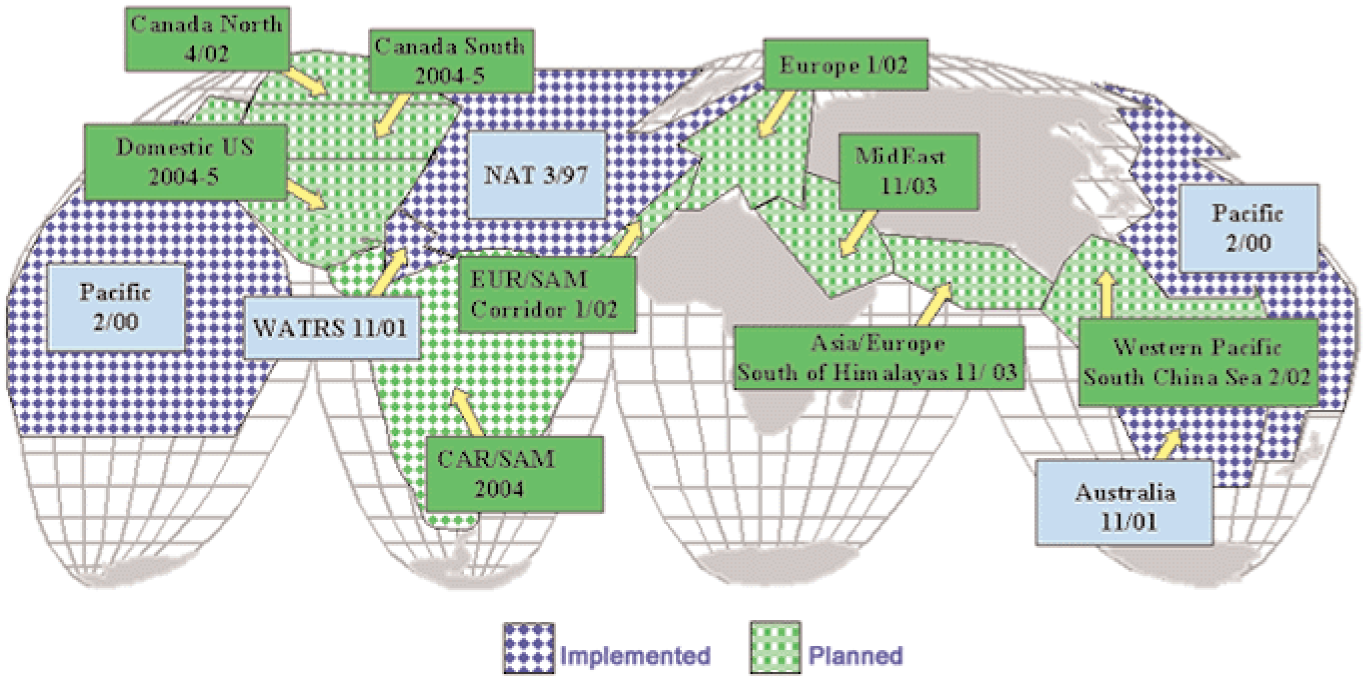

- Mitigates conflict points
- Enhances volume of aircraft that can be accommodated in a given sector (sector throughput)
- Enables crossing traffic flows to be accommodated
- Reduces controller workload (e.g., reduced vectoring and flight level changes)
- Provides for growth in NAS en route airspace capacity

As a traffic management tool, RVSM is an internationally established practice. It is already in effect in Europe and Australia and over most of the North Atlantic and Pacific oceans. Canada plans to implement RVSM in its southern airspace (it is already in effect north of 57 degrees) at the same time as the U. S. Caribbean and South American countries also plan to join the U. S. and Canada in implementing RVSM in 2005.

Research and Development Activities

The FAA is implementing domestic RVSM in January 2005 to give airlines and other aircraft operators time to install the more accurate altimeters and autopilot systems needed to ensure the highest level of safety. Because safety is paramount, the process of changing the current separation standard also requires research to assure safe operations under the new standard. As part of these efforts, researchers at the FAA's Technical Center completed an RVSM safety assessment in September 2004.

A key component of this assessment is to ensure that properly equipped aircraft can maintain a specific altitude. To collect the data necessary to determine if RVSM-approved aircraft can meet requirements, researchers developed a ground-based system to estimate aircraft geometric height. They are using this geometric height data, together with other information, to determine aircraft height-keeping performance.

This ground-based system is modeled on an aircraft geometric height measurement element (AGHME), coupled with a distance measuring equipment (DME) antenna. An AGHME listens passively for aircraft responses to Mode S interrogations (Mode S packets are information packets used in collision avoidance equipment, which also provide aircraft identification information). Upon receipt of the Mode S packet response, the AGHME stamps the receipt-time of the start of the packet very accurately. With a constellation of five AGHMEs, teamed with multi-lateration (a technique to determine the position of an object in three dimensional space), an operator can accurately gauge the geometric height of the aircraft that is emitting the response.

Domestic RVSM

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One benefit of the AGHME system is that it is unstaffed. The system automatically monitors aircraft as they pass overhead. There-fore, it significantly reduces costs, while still being able to monitor many airframes in bulk fashion. With approximately 12,500 aircraft to approve, this system will be much more efficient, once its related standard is put into effect, than the present time- and man-intensive techniques.

Technical Center researchers have had primary responsibility to conduct simulation activities for Domestic RVSM (DRVSM). They conducted the first simulation in October 2001, issuing a final report in January 2002. The primary objective of this simulation was to assess the proper altitude strata for RVSM implementation. The results clearly demonstrated that a full implementation from flight level 290 through 410, in lieu of altitude bands of flight level 330 to 390 or 350 to 390, yielded superior results. Researchers also examined various other aspects of RVSM impacts, including the effect of a mixed environment in which non-RVSM approved aircraft were inserted into the otherwise exclusionary air space. A further review of these impacts is planned in future simulations.

The second DRVSM Simulation, conducted in June 2002, took a closer look at the impact of mixing non-approved aircraft in with the approved aircraft operating in RVSM airspace. In effect, such a mix requires controllers to apply two separation standards simultaneously within the same airspace. Additionally, this simulation assessed areas in which the nuances of RVSM would require new or modified procedures.

Researchers conducted the third DRVSM Simulation in June 2003. This simulation assessed new/modified procedures associated with the requirements of RVSM. Additionally, researchers conducted a closer scrutiny of the impact of non-approved aircraft. There are no additional simulations planned at this point. ❑

For more information regarding RVSM, please visit http://www.faa.gov/ats/ato/rvsm1.htm.

Creating the Network in the Sky

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Collaborative Information Environment. Each trend, when properly understood and integrated, will result in a new capability for aviation (and transportation) that will forever change the ability to access information while in transit. ❑

For more information, please visit www.AirborneInternet.com or contact Ralph Yost at ralph.yost@faa.gov.

Enhancing Human Performance

Bringing People & Technology Together

Studies estimate that human error contributes to 60 to 80 percent of all aviation incidents and accidents. As part of their efforts to understand the human-technology relationship, FAA human factors researchers are working to minimize the impact of human factors as a cause of aviation accidents. Through research in areas such as automation, workload, and communication, they are identifying the most effective procedures to be used in combination with new technology applications to ensure the global air transportation system of the future is safe and efficient. Their focus is on improving and standardizing methods for measuring and baselining human performance, gaining better insight into the environment's impact, and translating the knowledge gained into procedures, guidelines, and designs that will help enhance overall performance of aviation systems.

Human Factors Research

Aviation human factors research combines knowledge from the social sciences with principles of engineering. Experts study how humans think, see, hear, and coordinate their movements, especially when they are interacting with automated systems. The researchers sometimes work to refine what is known in these areas, or they may apply their knowledge to improve aviation tools, products, and systems.

Some areas where human factors can be applied to improve aviation safety, efficiency and effectiveness include: workload; functional design of systems and equipment; computer human interface; special tools; workspace, displays and controls; information requirements; visual and auditory alerts; input and output devices; communication and coordination; procedures development and refinement; anthropometrics; documentation development; environment; and display presentation.

The Research and Development Human Factors Laboratory

The FAA operates a state-of-the-art experimental laboratory at the William J. Hughes Technical Center designed to support human factors aviation research. This is a highly flexible, multipurpose facility with approximately 10,000 square feet of space. Researchers have access to any of four experimental rooms that, depending on the specific experiment, can be used separately or together. The four rooms can be linked to one another and to the central briefing room through video, audio, computer, and voice. While an experiment is in progress, observers can monitor progress unobtrusively.

The Human Factors Laboratory is a part of the FAA's Air Traffic Organization (ATO) and responds to the research and system acquisition requirements of a variety of service units within the ATO. The Laboratory works closely with the Human Factors Research and Engineering Division at FAA Headquarters to execute research defined by the research sponsors in the ATO service units. Since the service units oversee the operation and maintenance of the air traffic control system, they are also the developers of new or modernized systems. They regularly call upon the services of the Human Factors Laboratory to support the acquisition of these systems to assure that safety and human performance requirements are met.

The laboratory relies upon an "in-house" team of computer scientists and engineers, each skilled in a number of hardware and software tools. These professionals can create rapid prototypes of software, concepts, and interfaces proposed for future national airspace system use and help human factors researchers get an early start at a better understanding of any new relationship between operators and machines.

The laboratory's virtual reality capabilities allow researchers to interact dynamically with a three dimensional (3-D) graphical representations of concepts, designs, and data sets that might otherwise be too complex to visualize. Researchers can simulate operational environments related to airway facilities, air traffic control, or the cockpit to measure the effects of factors such as sounds and eye movements on human performance.

An advanced simulator for en route and terminal air traffic control systems called DESIREE, or Distributed Environment for Simulation, Rapid Engineering, and Experimentation is a unique feature of this lab. This tool precisely replicates the functions and user interfaces of FAA's display system replacement (DSR) and standard terminal automation replacement system (STARS). Developed by lab personnel, DESIREE can be configured to connect to any outside system to provide advanced decision-support, communications, weather, or surveillance information.

The Research

FAA's human factors specialists use this unique laboratory to ensure that humans "in the loop," who are operating and maintaining the sophisticated aviation systems, do the safest and most effective work possible. These specialists are comprised of engineering research psychologists, subject-matter experts from the air traffic control and airway facilities areas, and contractor support personnel. They support projects in nearly every area of FAA responsibility.

Human Factors research at the Technical Center is functionally divided into Air Traffic, Technical Operations, and System Acquisition Human Factors. Collocation of these areas of specialization at the laboratory allows seamless transfer of the full range of findings that must be considered as a project's life cycle moves from research to development and then on to acquisition.

Air Traffic - Human factors researchers are working with research sponsors in the ATO service units to understand how controllers do their jobs today and how they might be affected by future operational concepts, equipment, and procedures. They use realistic simulation tools to study how controllers perform in dynamic, complex environments. Current projects include work on determining the weather information needs of terminal controllers.

Accurate weather products are now available for the detection and prediction of precipitation, microbursts, storm motion, storm extrapolated position, and wind shear. New workstations that can display graphics and colors are also available. What is still missing, however, is an understanding of how better weather information can help terminal controllers to make better tactical decisions. To reach that understanding, the ATO Terminal Service Unit requested that researchers carefully study which sets of weather information, presented in which formats, provide demonstrable operational benefits.

Technical Operations - Researchers also examine issues that affect the safety, performance, workload, and job satisfaction of the people who monitor, diagnose, certify, maintain, manage, and restore major components of our national airspace system infrastructure. A current research project supporting the Technical Operations Service Unit involves helping airway facility specialists deal with increases in the number and type of computer input devices (ergonomic split keyboards, ergonomic mice, or scrolling mice).

As new systems are being built, acquisitions programs are seeking advice on whether to maintain the current keyboard, input device, or keypad configuration or change it. Researchers update Human Factors Design Standard information used by human factors practitioners on system design teams to provide accurate and timely information so that informed decisions can be made. This updated material will have crosscutting benefits for many programs. It will bring design guidance into line with current best practices and recent changes in input device availability. This project will enhance implementation of new technology. It cuts across virtually all programs with human factors content.

Systems Acquisition - Researchers are helping to integrate human factors policies, processes, and best practices into how the FAA acquires new systems. These specialists are involved with programs in the terminal, en route, system operators, flight service

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Phased Array Radar

Future Trends in Air Surveillance and Weather Radar

The FAA's Technical Center, with over four decades of achievements in innovative aviation systems, leads the way advancing state-of-the-art radar technology.

FAA researchers at the Center have entered into a unique research partnership with colleagues at the Department of the Navy's Office of Naval Research (ONR), the National Oceanic and Atmospheric Administration's (NOAA) National Severe Storms Laboratory, as well as researchers from industry and academia. The resulting Joint Phased Array Radar Project leverages resources in search of an affordable new radar technology that will deliver highly accurate severe weather information simultaneously with three-dimensional aircraft surveillance.

The Navy provided the initial funding and made essential equipment available on loan to the National Severe Storms Laboratory in Norman, Oklahoma. The project is an excellent example of technology transfer from the defense sector to the commercial aviation sector.

Phased Array Radar

Phased array radar uses an antenna with a flat plane arrangement of rows and columns of equally spaced radiating elements. Varying the number and spacing of the radiators within the array alters the width of the beam. A device known as a phase shifter allows the beam to be "steered" without actually moving the antenna. The resulting agile beam provides images that can deduce target range, bearing, and elevation, providing a significant advantage over traditional radar. The technology also delivers true multi-functional capabilities, including simultaneous surveillance and multiple target tracking functions.

In 1983, a phased array radar operating in S-band was placed in service on the Ticonderoga Class of U.S. Navy Aegis cruisers. S-band

is used for air surveillance, precision tracking and weather. The system quickly became a standard for air surveillance in defense communities throughout the world. Over a decade later, in 1996, the Navy began studying the clutter on the AN/SPY-1 screens. (In the radar community, the term "clutter" refers to any objects that cause unwanted reflections of a radar's electromagnetic energy to be returned to the radar receiver. The unwanted returns compete with valid returns of interest and cause the radar receiver and displays to become cluttered and more difficult to decipher.) Researchers discovered that weather conditions caused the clutter.

A comparison between the Navy's phased array radar and the FAA's NEXRAD (next generation radar) Doppler weather radar systems showed that the phased array radar had the potential to detect weather phenomena. The Navy placed a phased array radar weather processor (known as the Tactical Environmental Processor or TEP) on the USS O'Kane for an at-sea demonstration of its weather capabilities. The ONR began funding research and development through the Department of Defense's Dual Use and Science Technology program to investigate the affordability of this new application.

Current Activities

FAA, Navy, and NOAA researchers have successfully demonstrated the concept of using phased array radar to perform surveillance and weather functions. They have found that this system characterizes the atmospheric environment much the same as the NEXRAD Doppler weather radar system, but much faster. Reflectivity, velocity, and spectral width of matter in space is analyzed and updated at a one-minute rate.

The phased array radars now available for large-scale weather analysis are known as passive array systems. Research has begun to replace their transmitter chain with experimental active array components that employ several thousand individual, duplexed transmit/receive (T/R) modules. Use of these modules will preserve energy and allow better focusing of the radar beam, making it possible to control multiple beams simultaneously and achieve much faster scanning.

The costs of a T/R module has already decreased, and are expected to continue to decline. Since the antenna is the most costly component of the radar, researchers are working to make phased array technologies more affordable. Research in the materials used in phase shifter technology also looks promising. Current promising technology advancements include Active Array Technology using solid-state Microwave Monolithic Integrated Circuitry (MMIC), which utilizes semiconductor material such as Gallium Nitride (GaN), Gallium Arsenide (GaAs) or Silicon Carbide (SiC). Use of these T/R modules eliminates much of the RF energy lost in today's MMICs. Further advantage can be gained from applying digital adaptive beam-forming techniques to groups of modules within the array. Other engineering techniques under consideration include using algorithms to modify the system's volume scan strategy to let controllers track uncooperative targets or study storms as they are forming.

The next step for team members is to take advantage of newer lower cost technology and integrate a truly multi-functional phased array radar test bed. Some of the new functions and applications under consideration include aircraft tracking and surveillance, wind profiling and chemical/biological profiling. Success with Phased Array Radar technology in defense applications together with cost saving technology advances in manufacturing make this technology a real contender for the next generation of weather and air surveillance radars in the commercial aviation field. The net result of the Technical Center's active role in advancing the state-of-the-art in radar for air and weather surveillance and aircraft tracking is safer skies and greater capacity at the nation's airports. ❑

For more information on the FAA's phased array radar program, please contact William Benner at william.benner@faa.gov.

Traffic Management Advisor

Easing Congestion at Busy Airports

The Traffic Management Advisor (TMA) is an automated tool that helps air traffic managers to make safe, efficient decisions as they route aircraft into busy U.S. airports. In close collaboration with NASA and the aviation community, the FAA first introduced the system in 1994 at the Dallas/Fort Worth Airport. It quickly increased arrivals there by five percent. The FAA later expanded the program to include the air route traffic control centers in Oakland, Los Angeles, Denver, Minneapolis, Atlanta, Miami, and Houston. TMA is currently being installed in Chicago. Overall, increases in TMA-supported arrivals have grown to ten percent. A proven success, TMA is now being adapted to service the most densely populated portions of the nation.

The Classic Challenge - and the Classic Toolset

Air traffic management staff and controllers continually adjust the stream of aircraft entering and moving through particular airspace to meet, but not exceed, the operational capacity of airports. This is difficult work. Conditions on the ground and in the air often change quickly, as do weather conditions. Travelers, pilots, airlines, and airports want flights to arrive as scheduled, but they also expect the FAA to keep safety paramount.

Over the years, air traffic managers have tested procedures to move aircraft safely toward and away from airports. Separation has remained the central element. The classic controller toolbox contains information, such as flight intent information, radar reports and weather information.

Each of these tools has been improved many times. Today's radar reports are enhanced with aircraft identity, airframe type, and provide information such as current altitude, altitude transition, speed, flight information, and a few other characteristics. The quality and specificity of weather information has also been enhanced greatly in recent years. Automated flight planning tools have also increased the currency of flight intent.

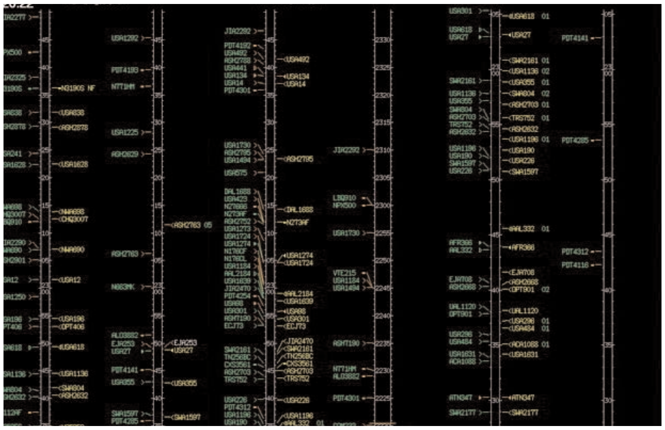
As a set, the standard controller tools bring in a steady flow of answers to questions like: What is the current state of the aircraft and what is the intended path through the airspace? How will weather conditions change the intended path? Before TMA the air traffic managers were left to interpret the complex interactions of aircraft state, aircraft intent and weather dynamics largely on their own when separating and sequencing aircraft. They relied on their experience and procedures, and they did a remarkable job of building and preserving the world's safest airspace system.

When sectors of airspace become congested, senior traffic managers have generally advised controllers to increase the separation between aircraft flying on the same route. This "miles-in-trail" spacing might be 10, 15, 20, or more miles between each aircraft. While miles-in-trail is generally a reliable tool, it does not adapt efficiently to changing conditions. Under certain conditions, the controller may sense an opportunity to vary in-trail criteria between pairs of aircraft. It may seem likely, for example, that no aircraft will be in place to merge into a downstream position that is slated for landing. While the slot held for that "unlikely" aircraft may appear to be wasted, the controller does not act on this intuition in the absence of supporting data analysis.

Air traffic managers have also eased congestion many times by delaying the departure of a particular aircraft until it could be fitted into a high altitude airway slot pointed toward the appropriate destination. Again this is a prudent technique to lessen the load on the destination airport but it is difficult to employ without the supporting planning aids that can confirm the accuracy of the particular procedure.

Problems with the Classic Model

These combined strategies and procedures reflect an operating environment in which con-



trollers "see" only the airspace bounded by their assigned sectors. Although they have maintained a three-dimensional view of their "own" traffic, they may sometimes have focused too readily on points in their sectors where conflicts have been known to arise. As a result, they may not perceive the variety of options that might solve problems across sectors.

Controllers also have lacked the supporting data that would have allowed them to grant pilots permission to vary from established flight plans. In retrospect, many requests may have proven to be viable, but it remained prudent, at the time of the request, to rely on time-tested procedures.

The Original TMA Solution

As part of the Free Flight initiative, the FAA and NASA began working on a solution to expedite air traffic arrivals into busy airports and allow production of updated, dependable arrival schedules. The resulting TMA technology continuously compares current data on the progress of aircraft destined for an airport with that facility's current arrival capacity. It then advises air traffic management how to route and space approaching aircraft and to balance the assignment to all available runways.

New strategic management tools took in many factors to compute the combined anticipated trajectories of aircraft in flight - and even those soon scheduled to be in flight. For the first time, controllers received estimates of conditions expected at merge points and airports. Controllers could actually take note of conditions beyond their own sector boundaries to build efficient traffic flows and ensure required upstream separation. They could use every slot with confidence. They could safely remove longstanding restrictions. They could even provide some of the service efficiencies long requested by pilots and airlines.

Although TMA could be set up to provide miles-in-trail advisories, the system proved to work better when estimating the amount of necessary delay in minutes. Known as "time-based-metering," this new method combines knowledge of the airport acceptance rate with aspects of current and future traffic conditions to anticipate downstream point crossings at times needed to meet TMA-generated schedules. To ensure that the schedules conform to actual emerging events, they are updated with each new sweep of the radar.

In the traffic management unit of the air route traffic control center, the assigned traffic management coordinator views an overall time-based schedule on a special graphical user interface. The radar controller also receives a current "meter list" of all aircraft currently in the sector. Based on the displayed information, the coordinator might modify the schedule to input additional information, possibly indicating the closure of a runway for a future period of time or expediting a particular aircraft due to an on-board emergency.

Time-based-metering is also more easily used by the traffic management coordinator than is a distance-based schedule. The coordinator can more readily see the difference between the TMA-generated schedule and the current situation to get a quicker idea of the workload being assigned to the sector controller. The coordinator also can get a quick picture of the anticipated aircraft load, including flights that are not yet airborne. A graphic pop-up window also shows the coordinator the demands anticipated at specific metering points, or at the airport, comparing traffic that is metered and un-metered.

The Challenges

While the technology and procedures of the original TMA installations have produced encouraging results in major U.S. airports, they are not suitable for use in all facilities. Scheduling arrivals of the air traffic associated with Philadelphia International Airport, for example, would present a significant challenge to a single TMA working with in a single center.

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Philadelphia resides in the most densely populated part of the United States, known as the Northeast Corridor, which stretches about 500 miles from Washington, DC, to Boston, Massachusetts. Major airports

in the corridor include Dulles and Reagan National, Baltimore-Washington International, Philadelphia International, Newark, New York's LaGuardia and Kennedy, and Boston's Logan. The relative proximity of these busy airports, as well as the many smaller airports in the region, have evolved into a heavily traveled, complex airspace with narrow airspace sectors, routes with many merge points, rigorous procedures, and frequent spacing restrictions. When traffic in this airspace becomes excessive, flight paths become inefficient, and air traffic control facilities responsible for the terminal airspace around the major airports routinely refuse to accept more aircraft.

Five daily arrival rushes affect Philadelphia at 8:00, at noon, and at 4:00, 6:00, and 8:00 at night. Congestion increases when poor weather conditions at the airport limit landings to a single runway or when generalized bad weather reroutes traffic through an alternate Philadelphia airspace entry gate.

The complex airspace characteristics of the Northeast Corridor would force any schedule for aircraft coming to Philadelphia to be based on data originating farther away from the airport than for any previous TMA site. Although it is normal to begin scheduling arrivals about 200 miles from the airport, a Philadelphia schedule would require about 300 miles, and would draw upon data from the New York, Washington, DC, Boston, and Cleveland air route traffic control centers. This would require a true Multi-Center TMA or, in shorthand, a TMA-MC.

The TMA-MC Solution

When it became clear that a traditional TMA would not work for Philadelphia, FAA and NASA researchers developed a prototype TMA-MC using Philadelphia as a testbed. The project began in 2001 and is expected to finish in 2005. These evaluations in-volve the four air route traffic control centers, one terminal radar approach control facility, and the FAA's Air Traffic Control Systems Command Center.

Researchers are using existing TMA software as a baseline for TMA-MC to facilitate compatibility of use and ease of update. The new application effectively combines the data of air route traffic control centers to create a "super-center" that pushes aircraft delays upstream into adjacent centers with no direct feed into the Philadelphia Airport. Traffic management alternatives can thus be plotted up to 90 minutes into the future and the facilities can effectively collaborate to meet, but not exceed, the acceptance rate of the subject airport.

The new system takes characteristics of the collaborating centers into account. Each center is assigned a delay "budget" based on the amount of delay it can reasonably absorb. For example, the Cleveland Center's delay budget is about ten minutes, much higher than the highly restricted New York Center's three to four minutes. In the collaborative calculations for Philadelphia Airport, the New York Center is the "controlling TMA." The controlling TMA gathers data on aircraft at the other centers as well as its own. It then assigns the schedule for metering points into the Philadelphia terminal airspace and conveys this schedule to the installations at the other three centers. In response, they adapt the schedules for their own metering points to meet the New York schedule.

Ongoing Research Activities

The FAA's William J. Hughes Technical Center, whose researchers and engineers have been involved with TMA since the beginning of prototype testing, now hosts a full 4-Center TMA-MC equipment suite in its Technology Integration Laboratory.

Specialists at the Technical Center perform non-interference testing for each new complete and interim version of TMA-MC. They also are working with their counterparts at NASA to simulate an effective environment in which human-in-the-loop testing can be completed before the new application is used in the field. They also are providing training to controllers in the techniques of time-based-metering.❑

For more information regarding TMA-MC or the laboratories at the FAA's William J. Hughes Technical Center, please contact Dominic "Bud" Timoteo at (609) 485-4055

Continuing Partnerships

Joint University Programs

The FAA/NASA Joint University Program for Air Transportation Research (JUP) is a partnership of three universities, conducting long-term scientific and engineering research to improve the safety and efficiency of the National Airspace System. Under the JUP, the FAA and NASA provide research grants to the Massachusetts Institute of Technology, Ohio University, and Princeton University. JUP research covers a broad scope of technical disciplines, including, but not limited to air traffic control theory, human factors, satellite navigation and communications, capacity issues in air traffic control, synthetic vision, and meteorological hazards.

The JUP is a long-term cooperative partnership between FAA and NASA to pursue common research goals by promoting research and education in selected aviation technologies. The program is dedicated to the principle that solutions to large-scale system problems in the National Airspace System (NAS) come only after the technological foundations have been laid through long-term basic and applied research. These concepts are well established in the JUP's guiding interagency Memorandum of Agreement, which states: The objective of this program is to provide access to, and dissemination of the long range, innovative research in civil aeronautics related technologies under development at American colleges and universities. A secondary benefit is the creation of a talented pool of graduates trained in engineering and scientific disciplines to advance the state-of-the-art in aviation technology in government, industry, and academic communities.

This secondary benefit is illustrated in a recent quarterly review meeting where a special guest speaker, Dr. Sandeep S. Mulgund (a lead systems engineer and researcher at MITRE Corp.) presented his current research on a traffic flow tool. He is a Princeton graduate and a product of the JUP. Furthermore, he works within a MITRE team where two others are also graduates from the JUP.

The JUP provides an interdisciplinary team approach to research and education in aviation technologies. By bringing this multi-agency, multi-university approach to bear on large-scale National Aviation System management and technical problems, highly original and creative solutions emerge.

Students conducting research under JUP auspices have won a number of national awards, such as the RTCA William E. Jackson Award, the FAA's Excellence in Aviation Award, AIAA Foundation Orville & Wilbur Wright Graduate Award, and NASA's Student Aviation Design Competition. Most recently, JUP graduate, Dr. Tom Reynolds of MIT, received both the 2003/2004 AIAA Foundation Orville & Wilbur Wright Graduate Award and RTCA William E. Jackson Award.

The universities seek validation and suggestions for improvement of their research, as well as proposed new avenues for investigation via a series of quarterly reviews with the FAA and NASA. These reviews are conducted at the campuses of the participating academic institutions, as well

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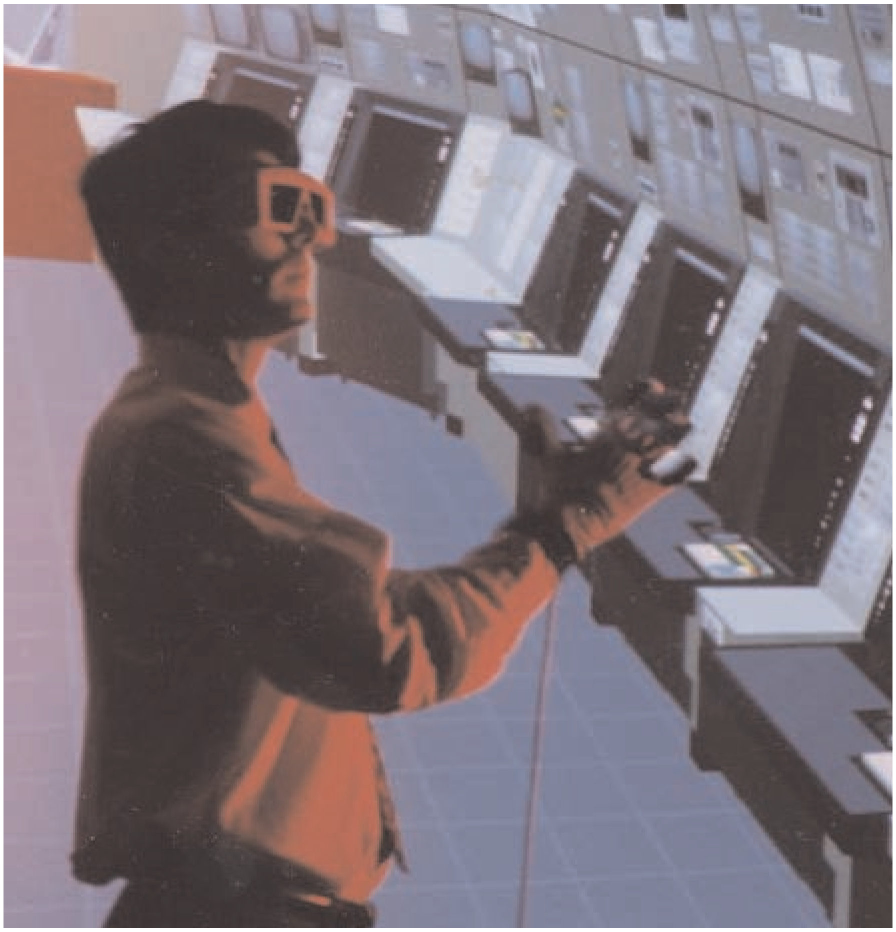

as at the sites of the governmental sponsors. The latest review will be hosted by the Technical Center on January 27-28, 2005.

Through the JUP program, NASA and the FAA leverage their resources, enabling them to achieve better high-priority goals. They benefit directly from the results of specific research projects, and, less formally, from valuable feedback from university researchers regarding the goals and effectiveness of government programs.

Current JUP research topics include:

Massachusetts Institute of Technology

- Incorporation of Safety Based Enhancements on General Aviation Primary Flight Displays
- Safety Considerations for Operations of Difference Classes of UAV's in the NAS
- Controller Cognitive Complexity Limitations and the Impact of Airspace Structure
- Analysis of regional Jet Operating Patterns in the US
- Emergence of Secondary Airports in the US
- Profitability Dynamics of the US and World Airline Industry
- Analysis of barriers to transition in air transportation
- Human Centered Development of Next Generation Oceanic ATC System in Collaboration with Iceland CAA

Ohio University

- Peripheral Vision Display for General Aviation
- Global Positioning System/Inertial (GPS/INS) Flight Testing

Princeton University

- Reduction of Noise and Fuel Consumption. ❑

For more information on points of contact, background, schedule of upcoming meetings, and access to an extensive archive of presentations and abstracts on the research, please contact Teri Lowe at teri.lowe@faa.gov.

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domains. Human factors researchers supported a concept evaluation of the New York integrated control concept (NYICC). This proposal would collocate terminal and en route air traffic controllers and expand the airspace that can use terminal separation standards in current en route areas. The researchers conducted two, high-fidelity, human-in-the-loop simulations. One experiment examined arrival traffic flows and the other examined departure traffic flows.

Together these studies demonstrated how proposed changes in controller communication, workload, and performance would affect overall system efficiency. Both experiments compared three parallel sets of conditions. In the "normal" condition, the controllers worked with a wall separating the terminal and en route sectors. In the "collocated" condition, the wall was removed so terminal and en route controllers could communicate face-to-face. In the "terminal" condition, all controllers were located together and lateral separation standards were reduced for particular en route sectors. Results indicate of the concepts, show potential benefits.❑

For additional information on the human factors work being done at the William J. Hughes Technical Center please see the FAA's human factors research program at, www.hf.faa.gov

Editorial Notes

R&D Review is a publication of FAA's Operations Planning Research & Development Office, produced for and distributed to researchers from industry, academe, and government.

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needed to develop and deploy new technologies. According to Elizabeth Soltys, the FAA's Technology Transition NAS Program Manager, "the agreement allows for early FAA involvement in NASA development projects, ensuring the FAA's Air Traffic Organization's mission to provide safe, secure, and cost effective air traffic services that our owners expect, now and into the future."

In addition to describing the roles and responsibilities of each Center, the inter-agency MOA prescribes the use of implementation plans to detail the objectives, scope, elements of performance, resources, responsibilities, authorities, schedule, and products associated with each technology transition task to be undertaken. To date, 29 implementation plans have been developed. Those plans cover the gamut from a specific technology development project to buying equipment and contracting support. Several of these plans involve co-locating FAA personnel to NASA Ames Research Center. Two FAA engineering research psychologists and one aviation technical system specialist currently work full-time at NASA Ames.

One of the collaborative technology projects is the En Route Descent Advisor (EDA), an automated decision support tool intended for use by en route controllers to handle traffic in transition airspace (i.e., hand offs to terminal radar approach controllers). EDA provides controllers with maneuver advisories so they can guide arrival aircraft across terminal radar approach control (TRACON) metering fixes in accordance with scheduled time-of-arrival and sequence constraints, while guaranteeing separation assurance and maximizing fuel efficiency.

As a component of the Center-TRACON Automation System (CTAS), EDA is intended to improve the efficiency and throughput of the national airspace system to meet the objectives of the FAA's National Aviation Research Plan and NASA's Aerospace Technology Enterprise program. EDA also has the potential to increase controller throughput and efficiency while reducing workload. It brings to the controllers:

- Predictions of possible conflicts for all air traffic (arrivals, departures and over-flights)
- Functions that range from manual "what-if" input and feed back generation of resolution advisories (suggested solutions to a congestion problem)
- Aircraft route predictions based on the type of aircraft, atmospheric conditions, and airspace procedures

Controllers receive flow-rate and separation constraint advisories for metered aircraft arrivals from EDA, which have been integrated with conflict detection and resolution capabilities. The advisories include cruise speed, top-of-descent, descent speed, altitude, and flight path for fuel-efficient and conflict-free descents with accurate arrival times. By making use of trajectory predictions involving aircraft type, atmosphere, and procedures, EDA supports both strategic and tactical decision making with time horizons up to 25 minutes.

EDA is being developed in a series of developmental phases. The FAA is currently assessing an early research prototype using high-fidelity controller-in-the-loop evaluations with both live and simulated air traffic. During this phase of evaluation, researchers will also undertake benefits studies and human factors engineering of the tool. Simulation results will be used to refine design requirements, which will lead to the completion and validation of a concept development prototype capable of supporting controller evaluations with actual aircraft, thus transitioning from research to development.

Air Route Traffic Control Center (ARTCC) field-test evaluations and implementation are anticipated with future product refinements. Following initial field trials, researchers will work to integrate EDA with aircraft flight systems through two-way data-link to provide additional benefits to controllers and airspace users.

When deployed into the NAS, this tool will provide controllers a decision support tool that will enable efficient handling of en route arrival flights in the airspace leading from high altitude to ground level at the terminal. (For information on another FAA/NASA technology development project, the Traffic Management Advisor - Multi-Center, please see the article on page 18.)

"The technology transition program is providing great benefits," says Soltys. "By working jointly in areas of mutual concern, sharing knowledge and resources, and deploying new air traffic management technologies, the FAA and NASA ensure that key technologies are available to the flying public."❑

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