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Air Traffic Control Modernization

Statement of
The Honorable Kenneth M. Mead
Inspector General
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Mr. Chairman and Members of the Subcommittee:

We appreciate the opportunity to discuss the Federal Aviation Administration's (FAA) air traffic control modernization efforts. From Fiscal Years 1982 through 1999, the Congress appropriated over $27 billion for the modernization program. FAA estimates that the effort will need an additional $14 billion for Fiscal Years 2000 through 2004.

We would like to recognize the actions of Administrator Garvey to facilitate our oversight of FAA's modernization programs. Through the Administrator's example, we have attended meetings where open, candid discussions were permitted and solutions were discussed.

Modernizing the Nation's air traffic control system is critical to meet the demands of a dynamic and growing air transportation system. The Modernization Task Force has resulted in more focus to the modernization effort and a better understanding of risks and challenges. This Task Force has contributed to making projects more manageable and provided a vehicle for FAA to gather input from diverse segments of the aviation community.

Today, we will discuss four issues:

- ✓ Progress and problems over the past year with significant modernization programs,
- ✓ "Common threads" that account for schedule delays and cost growth,
- ✓ Opportunities with Free Flight and Data Link, and
- ✓ The status of Year 2000 efforts and a technology to reduce runway incursions.

First, there have been several successes in the past year. They include the Display System Replacement (new controller displays and consoles at en route centers) and the HOST computer replacement (mainframe computers at en route centers). However, two key modernization programs, the Wide Area Augmentation System (WAAS) and Standard Terminal Automation Replacement System (STARS), continue to experience problems that need FAA's attention. WAAS will augment the Global Position System for civil aviation use. STARS will provide new controller displays and maintenance workstations, as well as computers and software, for over 170 terminal air traffic control facilities. We have recently made recommendations to FAA concerning software development, human factors, and schedules for STARS and the costs of a back-up system for WAAS.

Second, there are "common threads" associated with FAA modernization programs that have experienced difficulties. These include intensive software development,

human factors issues, and unrealistic schedules. FAA attention to these areas can prevent a repeat of past problems.

Third, FAA has opportunities to improve its management of software development and human factors issues with new programs, such as Free Flight Phase 1 and Data Link. Free Flight is a new concept of air traffic management that will permit pilots and controllers to work together to share information and manage air traffic. Data Link offers a new way for controllers and pilots to communicate and is analogous to electronic mail where a person can send a message to other people without speaking to them. These programs are in early stages of development, and we believe there is time to address these issues.

Finally, there are other modernization efforts underway that are essential for the efficient operation of the National Airspace System and improving safety. These efforts include FAA's Year 2000 computer compliance and the Airport Movement Area Safety System.

Regarding Y2K compliance, FAA has made important progress in the past year, but major challenges remain with respect to implementation in the field. We have concerns about the international arena, such as foreign air traffic control. There are many "unknowns" about Year 2000 readiness outside of the U.S. A policy should be developed as to whether U.S. carriers or U.S. code share flights (cargo or passenger) will be allowed to fly to countries that are not known to be Year 2000 complaint.

The Airport Movement Area Safety System is critical to reducing runway incursions, which have increased 75 percent since 1993. This system also has experienced problems, and the scheduled August 2000 date for final system installation is high risk.

PROGRESS AND PROBLEMS WITH FAA MODERNIZATION PROGRAMS

Over the past year, there have been several success stories, such as the commissioning of the first Display System Replacement at Seattle's Air Route Traffic Control Center. Also, new HOST computers have been delivered to 19 en route centers, and controllers at 14 centers are now using them to control air traffic on a full-time basis.

- ***First Display System Replacement (DSR) Site is Dedicated***: ($1 billion in program costs) DSR modernizes en route traffic control centers by replacing aging and unsupportable display equipment. DSR features new color displays and consoles for controllers. It uses modern computer processing technology for improved speed, capacity, maintainability and reliability. DSR can be easily upgraded with hardware and software enhancements. It is important to note that

considerable software for DSR was developed as part of the Advanced Automation System.[1]

The first site, Seattle, was dedicated in January 1999. DSR has been delivered to 17 of 20 domestic en route centers. DSR is on schedule to have all 20 sites operational by May 2000.

- ***Progress Made with HOST Replacement***: ($173 million for Fiscal Years 1998 and 1999) The HOST replacement program will replace the mainframe computers at the 20 domestic and Anchorage Air Route Traffic Control Centers, 3 oceanic and offshore sites, and 4 support facilities. In December 1997, FAA decided to replace the HOST computers 4 years earlier than expected because of uncertainty over Year 2000 compliance and, more importantly, supportability problems. To minimize risk, FAA developed a four-phased approach to implement the HOST replacement. Phase 1 replaces the mainframe computer by the Year 2000 and does not involve extensive software development. FAA plans to complete Phase 1 by October 1999. Phases 2 through 4 will involve extensive software development and the replacement of peripherals by July 2001.

  FAA has made progress with its program to replace the HOST computers. Currently, new HOST computers have been delivered to 19 centers, and controllers at 14 of these centers are now using the computers to control air traffic on a full-time basis. To ensure that the HOST replacement remains on track, we recently recommended that FAA reach agreement on contract cost and terms without further delay.

However, two key modernization programs, the Wide Area Augmentation System and Standard Terminal Automation Replacement System, continue to experience problems.

- ***Wide Area Augmentation System (WAAS) Schedule Slips***: ($1 billion in program costs[2]) WAAS will augment the Global Positioning System[3] (GPS) for use in civil aviation. It will provide the capability to navigate in the en route environment and allow precision approaches to some airports in the continental United States. WAAS continues to experience schedule slippage.

[1] For additional details, see Advanced Automation System (Report Number AV-1998-113, April 15, 1998).
[2] The $1.0 billion in Facilities and Equipment program costs for WAAS includes the prime contractor costs (including the terminated Wilcox contract), development of standards and procedures, technical engineering and program support, and the first year of communications costs for satellites. The WAAS lifecycle cost estimate of $3.0 billion through 2016 includes communications satellite costs estimated at $1.3 billion.
[3] The Department of Defense's GPS satellites transmit radio signals that allow properly equipped air, land, and sea users to calculate their position and speed anywhere on the earth's surface.

On January 5, 1999, FAA announced a revision to the implementation schedule for WAAS to allow more time to complete development of a critical software safety package. This software package determines the precise positions of the GPS and geostationary satellites, the effects of the ionosphere on the GPS/WAAS signal, and the validity of the WAAS message. As a result, the commissioning date for Phase I WAAS has been rescheduled to September 2000 from July 1999, a 14-month delay. This delay will undoubtedly require additional funding.

WAAS technical and program uncertainties must be resolved. These uncertainties relate to interference from unintentional and intentional jamming, ionospheric variation, and the number of communications satellites needed. A GPS Risk Assessment Study[4] concluded "GPS with appropriate WAAS/LAAS [Local Area Augmentation System] configurations can satisfy the required navigation performance as the only navigation system installed in the aircraft and the only navigation service provided by FAA."

The study provides valuable technical information on the effects of intentional and unintentional interference on GPS/WAAS and the significance of ionospheric corrections. The study identifies the need for two additional geostationary satellites to meet performance requirements. However, the study does not address how long it will take to develop measures to mitigate intentional and unintentional interference or their impact on FAA's program. Important questions exist about cost (for both FAA and airspace users), final user equipment, and milestones. Considerable work remains to be done.

It is plausible that the final system as envisioned by the study will not be in place until 2015. This is critically important because it raises questions about the role of the existing radio navigation infrastructure during the next 15 to 20 years. FAA estimates that the annual cost to sustain the existing radio navigation infrastructure is $170 million. Therefore, we have recommended that FAA include the costs of a back-up system of some type (for the next 15 years) in its current satellite navigation investment analysis. The costs should be based on detailed sustainability/supportability studies of existing navigation and landing systems.

[4] The Johns Hopkins University Applied Physics Laboratory, GPS Risk Assessment Study Final Report (VS-99-007), January 1999.

- ***Standard Terminal Automation Replacement System (STARS) Experiencing Cost and Schedule Difficulties***: ($940 million in program costs[5] but expected to be significantly higher) FAA's STARS Program will replace the current terminal automation system with a modern, fully digital system. STARS includes color radar displays and maintenance workstations, as well as computers and software, for over 170 terminal air traffic control facilities. STARS was designed to provide the software and hardware platform necessary to support such future air traffic control enhancements as a data link for controllers and pilots to communicate.

  Overall, the STARS Program has experienced significant cost growth and schedule delays. In September 1998, FAA informed the Congress that additional funding of $293.9 million might be needed to complete the STARS Program. This amount includes over $190 million for changes to the system's computer-human interface. The STARS schedule continues to be impacted by the software development needed to resolve human factors concerns and other new requirements.

  Because of concerns with equipment outages at the Ronald Reagan Washington National Airport terminal facility, FAA agreed to replace the controller displays sooner than originally planned. To accomplish this, FAA established the Early Display Configuration of STARS. It consists of new controller displays and maintenance workstations using the existing terminal automation system's (ARTS) computer processors and software along with the STARS emergency backup system. (In contrast, "full STARS" will completely replace ARTS with independent primary and backup systems.)

  FAA has recognized that it will not meet its March 31, 1999 schedule for initial operations of the Early Display Configuration at Reagan National. The Early Display Configuration schedule was very aggressive, with little time in the schedule if delays occurred. FAA was unable to meet the schedule because of the delay in the start of contractor testing and numerous software deficiencies identified during testing. In addition, 20 human factors issues remain unresolved.

  Last September, FAA estimated that initial operation of full STARS may not occur until June 2001, 30 months beyond the original December 1998 initial operation milestone for the Boston facility. Currently, FAA is in the process of

[5] Program costs include the Facilities and Equipment cost for the contract, program management and testing of systems. Lifecycle costs include the total cost of acquiring, operating, maintaining, supporting and disposing of a system over its useful life. The lifecycle cost estimate for STARS is $2.2 billion through 2025.

revising the schedules for the Early Display Configuration and full STARS, and additional delay will occur.

The Department of Defense (DoD), FAA's partner in the STARS acquisition, elected to receive full STARS with only a minimal number of the human factors changes requested by FAA's air traffic controllers and maintenance technicians. DoD's system is currently undergoing contractor testing for acceptance.

To provide FAA the opportunity to observe the full STARS system in an operational environment, we recommended that FAA defer decisions on the full range of human factors changes needed on full STARS until testing on the DoD configuration is completed. Once FAA and its controllers see how the DoD system performs, they will be in a better position to know what additional software changes are essential to address human factors concerns and whether they should be changed all at once or incrementally. However, FAA should continue to address the known human factors concerns in the full STARS system that have been identified for the Early Display Configuration.

COMMON PROBLEMS IN FAA ACQUISITIONS THAT NEED ATTENTION

There are "common threads" in FAA acquisitions that account for major schedule delays and significant cost growth. We believe three key interrelated factors – intensive software development, human factors issues, and unrealistic schedules – require FAA's attention.

- ***Intensive software development*** acquisitions have typically resulted in large cost increases and major schedule delays – an issue that has affected the pace of air traffic control modernization for more than a decade. Software problems proved to be the Achilles' heel of the Advanced Automation System, and similar challenges remain for programs such as WAAS and STARS. For example, WAAS, an intensive software acquisition, has experienced development difficulty in a critical software safety package that determines the precise positions of the GPS and geostationary satellites, the effects of the ionosphere on the GPS/WAAS signal, and the validity of the WAAS message. In contrast, the replacement of HOST computers, which is progressing on schedule, does not involve intensive software development.

  STARS is also experiencing software-related problems. Although the STARS acquisition plan was to maximize the use of a commercially available system, some development was anticipated. The initial contractor proposal estimated that 916,000 lines of software code could be used from its existing system and

that 119,000 lines of new software code would be developed. As of February 1999, FAA estimates that 370,000 lines of new software code will be required. FAA now considers STARS to be a developmental system.

FAA has recognized the need to improve its software development processes. Specifically, FAA has initiated activities to strengthen its software management processes by using an Integrated Capability Maturity Model[6] to improve the way it manages, engineers, and acquires software-intensive systems across all phases of the acquisition lifecycle.

FAA needs to consider a cost control mechanism for software intensive acquisitions. One option worth considering is a cost-plus-incentive fee arrangement to accomplish the work. This arrangement could inject an incentive sharing formula in what would otherwise be a cost reimbursable contract with limited contractor risk.

We recognize that improving the management of software intensive acquisitions is a long-term initiative that will not be easy. Given the complexity of FAA acquisitions, it is unrealistic to expect perfection in software development. However, effective software management is especially important in an environment of cost-reimbursable, software intensive contracts.

- ***Human factors*** examine how humans interact with machines and identify ways to enhance operators' performance and minimize errors. Given the variety and adaptability of human skills, no one solution will fully satisfy all users. Consequently, FAA must develop criteria for deciding how to weigh cost and schedule alternatives to determine which solutions to implement and when to implement them (i.e., before deployment or later during product improvement).

  The toughest decision, however, is determining when "enough is enough". FAA cannot satisfy everyone, and exit criteria can help in making some of the tough decisions. In our opinion, without exit criteria, FAA's costs to resolve human factors issues in the STARS Program will continue to increase.

  FAA has made significant progress in resolving STARS human factors issues identified by its air traffic controllers and maintenance technicians. However, more work is needed.

[6] The FAA Integrated Capability Maturity Model describes the essential elements of an organization's acquisition, engineering, and management process that must exist to ensure good acquisition of software intensive systems.

Specifically, in December 1998, controllers validated the contractor's implementation of the Early Display Configuration human factors design changes. The validation showed that for 7 of the original 98 human factors issues affecting controllers, the contractor's changes did not eliminate controllers' concerns and identified 10 new human factors issues for the Early Display Configuration. Further, 3 of the 52 human factors issues affecting maintenance technicians have not been resolved. FAA is currently assessing the impact of solutions proposed for the human factors issues on the Early Display Configuration's cost and schedule.

While progress has been made with Early Display Configuration human factors, the majority of human factors changes are expected to be needed for the full STARS system. The human factors changes for full STARS are expected to include the changes made to the emergency backup system (Early Display Configuration) plus a significant amount of changes to the primary system.

- ***Schedules that are unrealistic*** and do not take into account the risks associated with development affect FAA's credibility with the Congress and airspace users. Further, FAA must improve its planning and cannot afford to wait until the "11th hour" to announce a funding need to replace existing systems, as in the case of HOST.

  FAA can better manage risks by setting milestones that are not overly aggressive but achievable given the maturity of the technology. As an example, the STARS Early Display Configuration schedule for Reagan National was very aggressive and, in our opinion, did not include sufficient time to correct and retest any deficiencies identified during testing. Specifically, FAA planned to complete its operational testing only 5 days prior to the March 31 operational milestone.

  The HOST replacement is an example of the need for better planning to upgrade aging computer systems rather than waiting until the last minute when spare parts are scarce. The HOST computer system was installed in the mid-1980s and has not been upgraded since. In late 1997, faced with uncertainty about Year 2000 compliance and, more importantly, supportability issues, FAA had to make an "11th hour" decision to replace the HOST computers by 2000. As a result, FAA reprogrammed funds from other programs and established a very aggressive schedule in order to succeed by January 1, 2000.

OPPORTUNITIES WITH FREE FLIGHT AND DATA LINK

FAA has opportunities with new programs, such as Free Flight Phase 1 and Data Link, to improve its management of software development and human factors issues. Since these programs are in early stages of development, we believe there is time to

address these issues. Both of these programs offer considerable potential for more efficient handling of air traffic.

- ***Free Flight***: Free Flight is a new concept of air traffic management that permits pilots and controllers to share information and work together to manage air traffic. With Free Flight, pilots will not have to fly routes structured around ground-based navigation systems. As a first step, FAA and industry have agreed to move forward and deploy five technologies (see the Attachment) at limited locations by December 2002 through a program called "Free Flight Phase 1."[7]

  FAA recognizes that Free Flight Phase 1 faces many traditional challenges of past modernization programs, including software development, human factors issues, and complex integration issues. FAA is requesting $184.8 million for FY 2000, and estimates Free Flight Phase 1 will cost about $750 million through FY 2002--when Phase 1 will be complete. We caution that current cost estimates do not include costs for national deployment or changes in requirements that will likely occur. We are reviewing FAA's management of Free Flight Phase 1 projects with an emphasis on the risks associated with software development and human factors.

- ***Data Link***: To relieve congested voice channels, FAA and industry are moving forward to implement a data link for controllers and pilots. In its simplest form, data link is analogous to electronic mail, where a person can send a message to other people without speaking to them. After significant delays and a lack of agreement, FAA and industry have agreed on a general path to implement data link in domestic airspace. FAA intends to implement data link at the Miami Air Route Traffic Control Center in June 2002 leading to a national deployment beginning a year later in June 2003, at a cost of $645.5 million through 2015. We have made recommendations[8] aimed at improving FAA's management of Data Link efforts, mitigating risks, and making future efforts more cost effective.

  The introduction of data link has far reaching human factors implications for controllers and pilots. For example, an important issue is how controllers and pilots will use two distinct communication systems (voice and data link) to share important information. Controllers will be expected to handle both data link and non-data link equipped aircraft in the same airspace. Similarly, pilots will fly in and out of airspace where data link is not universally used. This could lead to additional workload for controllers and pilots.

[7] The five technologies are User-Request Evaluation Tool, Traffic Management Advisor Single Center, Passive Final Approach Spacing Tool, Collaborative Decision Making, and Surface Movement Advisor.
[8] Report on FAA's Progress and Plans for Implementing Data Link for Controllers and Pilots (Report Number AV-1999-057, February 24, 1999).

OTHER EFFORTS ESSENTIAL TO AVIATION SAFETY AND EFFICIENCY

There are other modernization efforts underway that are essential for the efficient operation of the National Airspace System and improving safety. In this regard, we would like to make observations about FAA's Year 2000 compliance and the status of a key technology that has the potential to reduce accidents on airport runways.

- ***Year 2000 Compliance Still Faces Challenges***: ($305 million in program costs) A top priority for FAA is to ensure that mission critical computer systems properly process data in the Year 2000 and beyond. FAA has 425 mission critical systems, and the 151 systems needing repair have been repaired. As of February 28, 1999, FAA completed repair on all necessary mission critical systems and had validated that 116 of these were working. FAA has implemented 41 of the repaired systems at field sites. FAA expects that all repaired mission critical systems will be validated and implemented by June 1999, 3 months behind the March 1999 target date set by the Office of Management and Budget.

  FAA still faces many Year 2000 computer challenges. Now that the 151 mission critical systems have been repaired, a copy of the software must be installed at each facility using the system. This is a major challenge because of the volume of activities and potential complications because facilities may have implemented software or hardware changes specific to their location.

  The Year 2000 problem has important implications for the aviation industry, including airports, aircraft manufacturers, parts suppliers, air carriers, and aircraft repair stations at home and abroad. As recently reported[9] by the General Accounting Office, U.S. airports have made progress in preparing for the Year 2000. The General Accounting Office noted that many airports are not following a comprehensive and structured approach for repairing systems and, consequently, are at risk of experiencing some equipment malfunctions. FAA has made outreach efforts and continued proactive attention is needed with national and international representatives in obtaining assurances that the air transportation industry will indeed be Year 2000 compliant.

- ***Airport Movement Area Safety System (AMASS) Schedule is High Risk***: ($89 million in program costs) AMASS is designed to continually monitor airport surface traffic and notify air traffic controllers of potential conflicts. AMASS uses data from the Airport Surface Detection Equipment (ASDE-3) radar to

[9] General Accounting Office, Year 2000 Computing Crisis: Status of Airports' Efforts to Deal With Date Change Problem, (GAO/RCED/AIMD-99-57), January 1999.

identify aircraft and vehicles on the airport surface. FAA plans to install AMASS at 34 airports nationwide by August 2000. AMASS is important because it can reduce the number of runway incursions. Runway incursions have increased 75 percent; from 186 in 1993 to 325 in 1998.

FAA began to develop AMASS in 1990, and since that time, the system has experienced technical, cost and schedule problems. To provide controllers the least number of false alarms, AMASS will be deployed with limited operational capabilities. Further, a human factors review of AMASS has yet to be completed. AMASS has experienced a $30 million cost growth due to software development issues. Additionally, AMASS is behind schedule. FAA is testing AMASS at three airports and the last installation will now occur at least 4 years later than planned. The scheduled August 2000 date for final system installation is high risk.

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Mr. Chairman, this concludes our statement. I would be pleased to answer any questions.

FREE FLIGHT PHASE ONE CORE CAPABILITIES

Capability	Functions	Planned Locations
USER-REQUEST EVALUATION TOOL (URET)	Provides en route controllers with future conflict situations, up to 20 minutes prior to the start of the conflict, and allows controllers to grant user requests or resolve conflicts through the use of trial planning capability.	Atlanta Chicago Cleveland Indianapolis Kansas City Memphis Washington, D.C.
TRAFFIC MANAGEMENT ADVISOR SINGLE CENTER (TMA-SC)	Generates statistics and reports about the traffic flow and computes the scheduled time of arrival and runway assignments for each aircraft.	Atlanta Chicago Dallas/Fort Worth Denver Los Angeles Miami Minneapolis Oakland
PASSIVE FINAL APPROACH SPACING TOOL (pFAST)	Calculates and displays landing sequence numbers and runway assignments.	Atlanta Chicago Dallas/Fort Worth Los Angeles Kansas City Minneapolis
COLLABORATIVE DECISION MAKING (CDM)	A collection of tools that allow the FAA and participating airlines to electronically exchange and analyze flight, NAS capacity and status information. It also enhances the traffic flow management process.	Air Traffic Control System Command Center Airline Operation Centers
SURFACE MOVEMENT ADVISOR (SMA)	Provides real-time ARTS III or STARS data about aircraft position and estimated touchdown time to ramp control operators.	Atlanta Chicago Dallas/Fort Worth Detroit Newark Philadelphia Teterboro