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NATIONAL AIRSPACE SYSTEM

FAA Has Implemented Some Free Flight Initiatives, but Challenges Remain

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Resources, Community, and
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The Honorable John McCain
Chairman
The Honorable Ernest F. Hollings
Ranking Minority Member
Committee on Commerce, Science, and
Transportation
United States Senate

The Honorable Slade Gorton
Chairman
The Honorable Wendell H. Ford
Ranking Minority Member
Subcommittee on Aviation
Committee on Commerce, Science, and
Transportation
United States Senate

In response to your request, this report discusses the results of our review of (1) the status of the Federal Aviation Administration's (FAA) efforts to implement free flight, including a planned operational demonstration formerly known as Flight 2000 and now called the Free Flight Operational Enhancement Program, and (2) the views of the aviation community and FAA on the challenges that must be met to implement free flight in a cost-effective manner.

We are providing copies of this report to interested congressional committees and subcommittees, the Secretary of Transportation, the Administrator of the Federal Aviation Administration, and other interested parties. Copies will also be made available to others upon request. Please call me at (202) 512-3650 if you have any questions about the report. Major contributors to this report are listed in appendix V.

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Executive Summary

Purpose

The predicted growth in air traffic and the aging of air traffic control equipment led the Federal Aviation Administration (FAA) to undertake a multibillion-dollar modernization effort in 1981 to improve the safety, capacity, and efficiency of the nation's air traffic control system. Since that time, this program has experienced substantial cost overruns, lengthy schedule delays, and significant performance shortfalls. To get the modernization effort back on track and thereby address the limitations of the present system and satisfy users' growing demands, FAA—in consultation with the aviation community—is developing a phased approach to modernization, including a new way of managing air traffic known as "free flight." Under the modernization program, FAA plans to introduce a host of new technologies and procedures that will enable free flight—allowing the agency to move gradually from its present use of highly structured rules and procedures for air traffic operations to a more flexible system in which decisions for conducting flight operations will be based increasingly on collaboration between FAA and users. For example, these technologies and associated procedures will give pilots and controllers more precise information about the location of aircraft and allow them to exchange information more efficiently. With more precise and efficiently exchanged information, pilots will have more flexibility to change their route, speed, and altitude (under certain conditions) with fewer restrictions, thus saving users time and money and allowing FAA to improve the air traffic control system's safety and use airspace and airport resources more efficiently.

Because FAA is at a critical juncture in its plans to implement this new system of air traffic management, the Senate Committee on Commerce, Science, and Transportation and its Subcommittee on Aviation asked GAO to monitor the progress of free flight initiatives and provide them with a series of reports. This first report discusses (1) the status of FAA's efforts to implement free flight, including a planned operational demonstration known as Flight 2000,[1] and (2) the views of the aviation community and FAA on the challenges that must be met to implement free flight cost-effectively.

Background

FAA's mission is to promote the safe, orderly, and expeditious flow of air traffic in the U.S. airspace system, commonly referred to as the National Airspace System (NAS). To accomplish its mission, FAA provides air traffic

[1]FAA officials working with the aviation community reached broad consensus on a general roadmap for restructuring the Flight 2000 program—including a recommendation that it be renamed the "Free Flight Operational Enhancement Program"—and presented this roadmap to FAA for formal approval in Sept. 1998.

services 24 hours a day, 365 days a year. The air traffic control system, which is the principal component of the NAS, comprises a vast network of radars; automated data processing, navigation, and communications equipment; and air traffic control facilities. Through the air traffic control system, FAA, among other things, controls takeoffs and landings and manages the flow of traffic between airports. Other components of the NAS include airports or landing areas; aeronautical charts, information, and services; rules, regulations, and procedures; technical information; and personnel and material.

Over the past 17 years, FAA has had an ongoing program to modernize the air traffic control system. Under this program, FAA is upgrading and replacing equipment and facilities and developing new technologies to help improve the safety, efficiency, and capacity of the system. However, this program has substantially exceeded its budget, encountered lengthy delays, and fallen short in its performance. As a result, the aviation community's confidence in FAA's ability to manage the modernization program has been weakened. While many of FAA's efforts under the modernization program, such as replacing controllers' workstations and supporting equipment, are not a part of the free flight initiatives, these efforts will provide the infrastructure that is critical for its implementation. To address the shortcomings in its modernization program and develop consensus on and commitment to the agency's future approach to both modernization and free flight, FAA has been working with the aviation system's users and their major trade organizations, representatives of air traffic control personnel, equipment manufacturers, the Department of Defense (DOD), and others (collectively referred to as stakeholders).

Free flight is a new system of air traffic management that will provide controllers and pilots with new technologies and procedures that will allow them to increase the safety, capacity, and efficiency of air traffic operations throughout the NAS. The implementation of free flight is expected to affect a wide range of users—from part-time pilots to major airlines—and allow many of them to take advantage of increased operating flexibilities. Despite the availability of such flexibilities to pilots, controllers will retain the ultimate decision-making authority for air traffic operations.

Results in Brief

Since 1994, FAA officials and stakeholders, under the leadership of RTCA, have been collaborating to implement free flight.[2] These early efforts led to a definition of free flight, a set of recommendations—most of which contain implementing initiatives—and an action plan to gradually move toward a more flexible operating system. While working to implement the recommendations, FAA and stakeholders agreed on the need to focus their efforts on deploying technologies that will provide early benefits to users. In early 1998, FAA and stakeholders developed a strategy that calls for the phased implementation of free flight, beginning with Free Flight Phase 1. Under this first phase, FAA and stakeholders have agreed upon the core technologies that are expected to provide these early benefits, as well as the locations where they will be deployed. However, until recently, FAA and many stakeholders have not agreed on how best to conduct a limited operational demonstration of free-flight-related technologies and procedures—known as the Flight 2000 program.[3] FAA is currently prohibited from spending any fiscal year 1998 funds on the Flight 2000 demonstration itself. Congressional conferees for the Department of Transportation's fiscal year 1998 appropriations act stated that additional financial and technical planning were needed before the demonstration program would be funded. Stakeholders concurred that FAA had yet to develop a detailed plan for conducting this demonstration. While they generally agreed with the need for such a demonstration, they have questioned whether the lessons learned from FAA's recommended demonstration, to be conducted primarily in Alaska and Hawaii, would be transferable to operations in the continental United States, where free flight operations will ultimately focus. To address the concerns of stakeholders, FAA has been working with them—under the leadership of RTCA—to restructure the Flight 2000 demonstration. FAA and stakeholders agreed on a general roadmap for the demonstration, including a recommendation that the demonstration be renamed the "Free Flight Operational Enhancement Program," and presented it to FAA for approval in September 1998.

Despite these efforts, FAA and stakeholders have identified numerous challenges that will need to be met if free flight—including Free Flight

[2]RTCA serves in an advisory capacity to FAA, making recommendations that are subject to approval by FAA. It was organized as the Radio Technical Commission for Aeronautics in 1935 to provide a forum where industry and government representatives could discuss aviation issues and develop consensus-based recommendations. In Nov. 1991, it reorganized and shortened its name to RTCA.

[3]Flight 2000 (now the Free Flight Operational Enhancement Program) is intended as a risk-mitigation demonstration of communication, navigation, and surveillance technologies planned for use under future phases of free flight.

Phase 1 and Flight 2000 (now the Free Flight Operational Enhancement Program)—is to be implemented cost-effectively:

- Stakeholders told GAO that FAA will need to provide effective leadership and management of the modernization efforts both within and outside the agency.
- Stakeholders cited the need for FAA—in collaboration with them—to further develop its plans for implementing free flight, including establishing clear goals for what it intends to achieve and developing measures for tracking the progress of modernization and free flight.
- FAA and stakeholders agreed on the need to address outstanding issues related to technology development and deployment, such as improving the agency's process for determining that new equipment is safe for its intended use and addressing the impact of modernization on human operators, including controllers, maintenance staff, and pilots.
- FAA and stakeholders also identified a range of other challenges that will need the agency's attention, including coordinating FAA's modernization and free flight efforts with those of the international community and integrating the various technologies that will be used under free flight operations with one another as well as into the air traffic control system.

Principal Findings

Status of Free Flight Implementation Efforts

In 1995, FAA and stakeholders defined free flight and outlined 44 recommendations—many of which have multiple initiatives—for consideration in implementing free flight.[4] In 1996, they developed an action plan with time frames to guide the implementation of these recommendations. Since that time, they have fully implemented 1 of 35 recommendations scheduled for completion by the end of 1997 and have made substantial progress toward completing initiatives under many of these and the remaining recommendations.[5] Under the fully implemented recommendation, FAA has incorporated airline schedule updates (e.g., airline delays and cancellations) into its Traffic Flow Management system to allow the agency to work more effectively with the airlines to reduce unnecessary operating restrictions and delays. In addition, under a

[4]The 44 recommendations were developed by FAA and stakeholders under RTCA Free Flight Task Force 3. This task force was conducted under the leadership of RTCA, a nonprofit organization that serves as an advisor to FAA.

[5]The remaining nine recommendations are scheduled to be implemented between 1998 and 2001/beyond.

recommendation to extend the benefits of data exchange, FAA has deployed digital displays of departure information in lieu of voice messages for pilots' use at 57 sites, as planned, and is currently working to expand the digital exchange of information about weather, airport, and facility conditions. Digital communications provide an advantage over voice communications by helping to relieve congested voice frequencies and reduce the number of operational errors that are caused directly or indirectly by miscommunication. Under another recommendation, FAA and stakeholders are working under the leadership of RTCA to improve the process that the agency uses to ensure that new technologies are safe for their intended use. Furthermore, as part of another recommendation, FAA has deployed technology—on a limited basis—to improve the sequencing of airplanes as they enter, depart, and operate within terminal airspace.

In addition to implementing the recommendations and their initiatives, FAA began to allow users to choose routes and use procedures (under certain conditions) that could save them time and money through two ongoing programs—the National Route Program and the Future Air Navigation System. In 1990, FAA launched the National Route Program to give users the flexibility to select and fly more direct routes. FAA estimates that the aviation industry saves over $40 million annually through participation in this program. Under the Future Air Navigation System program, which is conducted primarily over the oceans, new technology is used to improve the efficiency of communications between pilots and controllers. This technology, in combination with new procedures, is expected to provide them with more precise information on the location of aircraft so that distances between aircraft can be safely reduced—enabling users to save time and money. However, stakeholders told GAO that because FAA has not deployed the promised hardware and software infrastructure to support the use of these new technologies, the benefits to users have been marginal.

FAA's collaborative efforts with the aviation community to develop plans for implementing free flight have led to a general consensus on an incremental approach—beginning with Free Flight Phase 1—that would cost less for FAA and extend early benefits to users. This first phase is expected to provide these early benefits through the limited deployment of technologies that are intended to enhance the system's safety, capacity, and efficiency. For example, these technologies are expected to provide controllers with better information to detect and resolve potential conflicts between aircraft and to sequence traffic more efficiently. With such information, controllers will be able to give pilots increased flexibility to fly more optimal routes but will retain the ultimate authority for decision-making. FAA expects to implement Free Flight Phase 1 by 2002 and is currently developing a plan that will provide more details on implementing the program.

FAA and many stakeholders have disagreed on how best to implement Flight 2000—a limited operational demonstration of new technologies and procedures that was to be used under free flight to improve communication, navigation, and surveillance capabilities. Initially, FAA announced this initiative without consulting users, and disagreements persisted until recently, despite FAA's ongoing efforts to resolve them collaboratively. FAA believed that the Flight 2000 demonstration, as planned primarily for Alaska and Hawaii, was a means to mitigate the risks associated with implementing free flight. While many stakeholders agree with the need to mitigate risks, they have had strong reservations about conducting this demonstration in these remote locations, believing that the lessons learned there will not transfer well to operations in the continental United States. To address these concerns, FAA and stakeholders—working under the leadership of RTCA—developed a roadmap for restructuring Flight 2000 and presented it to FAA in September 1998. Among other things, this roadmap recommended that (1) the program be conducted in the Ohio Valley and Alaska, (2) nine major operational capabilities be implemented, and (3) the demonstration be renamed the "Free Flight Operational Enhancement Program." In developing this roadmap, both FAA and stakeholders emphasized the critical role of safety in achieving operational efficiencies, and many components of the program are designed to enhance safety. FAA is currently considering RTCA's roadmap. While FAA had planned to begin the Flight 2000 demonstration by 2000, time frames for the new demonstration are uncertain because issues such as funding and the need for additional planning have not been resolved.

Challenges to Implementing Free Flight Successfully

FAA and stakeholders generally agree on the phased approach to implementing free flight but have identified several challenges that must be addressed if free flight is to be implemented cost-effectively.

Effective Management Is the Key to Successful Implementation

Some stakeholders and FAA officials believe that strong FAA leadership is needed both within and outside the agency to successfully implement free flight. In particular, they maintain that FAA needs to encourage more effective communication and coordination among its various program offices responsible for modernization. According to some stakeholders and FAA officials, despite the agency's move to use integrated cross-program teams to improve coordination, this effort has fallen short because some participants are more beholden to their individual program offices than they are to the goals of the team. FAA has begun to develop incentives to encourage staff to work more cooperatively. As for FAA's leadership within the aviation community, some stakeholders cited the need for FAA to make and stick to its decisions so that they can move forward with their plans for free flight. While stakeholders recognize that FAA must balance competing priorities, they find it frustrating when the agency announces a course of action and then either drops the effort or moves in a different direction. Some stakeholders told GAO that this indecision has eroded their confidence in FAA's ability to lead modernization efforts, including free flight. Effective leadership will also be critical to successfully implement the planned evolutionary approach to developing and deploying technology and to demonstrate that FAA can effectively manage its air traffic control modernization programs and deliver promised capabilities.

Clear Goals and Measures and Sufficiently Detailed Plans Are Needed

To move safely and efficiently from the present system to free flight, stakeholders said that FAA needs to develop specific goals for what it intends to achieve and a system for measuring its progress. For example, one stakeholder cautioned that if FAA does not fully consider what the system needs to look like 10 to 20 years from now, it runs the risk of investing in technologies that may not address the system's future needs. In addition, some stakeholders and FAA officials agree on the need to develop baseline data for use in tracking their progress in improving the system's safety, capacity, and efficiency. As a next step, stakeholders maintain that the transition to free flight will require FAA to develop detailed plans for the various activities under free flight, including Free Flight Phase 1, Flight 2000 (now the Free Flight Operational Enhancement Program), and various follow-on efforts. Stakeholders told GAO that these plans need to include cost/benefit analyses to provide them with assurances that their investments in free flight technologies will result in benefits to quickly offset expenses. They also said that new procedures are critical to allowing them to fully exploit these benefits and expressed concern that such procedures will not be developed and implemented in a timely fashion.

Issues Related to Technology Development and Deployment Remain to Be Resolved

FAA and stakeholders recognize that certain issues related to the development and deployment of free flight technology need to be resolved. Chief among these issues is the need for FAA to streamline its process for determining that new equipment is safe for its intended use. However, several stakeholders cautioned that FAA will need to take care to ensure that changes to the process do not inadvertently compromise safety. FAA and the aviation community are currently working together to identify possible solutions. Many stakeholders also noted that successfully implementing free flight is inextricably linked to identifying and addressing issues associated with human factors. These issues include developing a reasonably paced training schedule to help ensure that pilots, controllers, and maintenance staff are not overburdened by too many changes at one time, as well as identifying risks associated with changes in technologies and procedures and the potential effects of these changes on human operations in a free flight environment.

Other Outstanding Issues May Limit the Effectiveness of Free Flight Implementation

FAA and stakeholders identified other challenges that must be met for free flight to be successfully implemented. For example, airlines that operate internationally and DOD believe that FAA needs to work diligently to ensure that, to the extent possible, users do not have to purchase multiple sets of equipment to meet different operating requirements in various parts of the world. While FAA is currently working with its international counterparts on various issues related to modernization—including issues related to free flight—some stakeholders question the sufficiency of the agency's efforts to coordinate technology selection decisions that will allow users to operate worldwide.

Some stakeholders and FAA officials cited the need for FAA to ensure that, to the extent possible, technologies will work together to maximize potential benefits. For example, FAA has new technologies that are expected to improve the efficiency of operations at high altitudes, close to the terminal, and on the ground. Because some of these technologies have not been designed to work together, some stakeholders and FAA officials contend that their potential benefits—e.g., allowing distances between aircraft to be safely reduced, when practical, throughout a flight's operation—will not be maximized unless the technologies are integrated. The agency recognizes that it does not have the internal expertise or experience to integrate the hardware and software that will be on board participating aircraft as part of the Flight 2000 demonstration (now the Free Flight Operational Enhancement Program) and plans to hire an integration contractor to do this work. Finally, stakeholders also stressed that the benefits of free flight depend on having adequate airport surface capacity (such as runways and gates) and question whether FAA is paying enough attention to the system's lack of such capacity. They noted that if users get to their destination more quickly, only to be delayed by limited airport capacity, they will lose some or all of the expected benefits.

Agency Comments

GAO provided copies of a draft of this report to FAA for its review and comment. GAO met with FAA officials, including the Director, Program Office, Free Flight Phase 1, and the Acting Program Directors for Flight 2000 and Architecture and Systems Engineering, who generally agreed with the contents of the report and provided clarifying comments that have been incorporated as appropriate.

Contents

Figures

Abbreviations

ADS	Automatic Dependent Surveillance
ADS-B	Automatic Dependent Surveillance-Broadcast
ARINC	Aeronautical Radio Incorporated
ARTCC	Air Route Traffic Control Center
ATC	air traffic control
ATIS	Automatic Terminal Information Service
ATM	Air Traffic Management
CDM	Collaborative Decision Making
CPDLC	Controller Pilot Data Link Communications
CTAS	Center TRACON Automation System
DOD	Department of Defense
DSR	Display System Replacement
DSS	decision support system
FAA	Federal Aviation Administration
FANS	Future Air Navigation System
FAST	Final Approach Spacing Tool
FIS	Flight Information Service
GAO	General Accounting Office
GPS	Global Positioning System
HF	High Frequency
LAAS	Local Area Augmentation System
MDCRS	Meteorological Data Collection and Reporting System
MIT	Massachusetts Institute of Technology
NAS	National Airspace System
NRP	National Route Program
PDC	Pre-Departure Clearance
pFAST	passive Final Approach Spacing Tool
R&D	research and development
RNAV	Random Navigation/Area Navigation
RVSM	Required Vertical Separation Minimum
SATCOM	Satellite Voice and Data Communications
SMA	Surface Movement Advisor
STARS	Standard Terminal Automation Replacement System
SUA	Special Use Airspace
TFM	Traffic Flow Management
TFM-ART	Traffic Flow Management-Architecture and Requirements Team

TIS	Traffic Information Service
TIS-B	Traffic Information Service-Broadcast
TMA	Traffic Management Advisor
TRACON	Terminal Radar Approach Control
URET	User Request Evaluation Tool
WAAS	Wide Area Augmentation System

Implementation of Free Flight Represents a Shift From Air Traffic Control to Collaborative Air Traffic Management

The Federal Aviation Administration's (FAA) mission is to promote the safe, efficient, and expeditious flow of air traffic in the U.S. airspace system, commonly referred to as the National Airspace System (NAS). To accomplish its mission, FAA provides services 24 hours a day, 365 days a year, through its air traffic control (ATC) system—the principal component of the NAS.[6] Predicted growth in air traffic and aging equipment led FAA to initiate a multibillion-dollar modernization effort in 1981 to increase the safety, capacity, and efficiency of the system. However, over the past 17 years, FAA's modernization program has experienced substantial cost overruns, lengthy schedule delays, and significant performance shortfalls. Consequently, many of the benefits anticipated from the modernization program—new facilities, equipment, and procedures—have not been realized, and the efficiency of air traffic control operations has been limited. In addition, the expected growth in air traffic will place added strains on the system's capacity.

To get the modernization effort back on track and thereby address the limitations of the present system and meet the growing demand for increasing its capacity, FAA—in consultation with the aviation community—is developing plans to implement a phased approach to modernization, including a new concept of air traffic management known as "free flight." To enable free flight, FAA intends to introduce a host of new technologies and procedures that will allow the agency to gradually move from its present system of air traffic control, which relies heavily on rules, procedures, and tight control over aircraft operations, to a more collaborative system of air traffic management. Under such a system, users would have more flexibility to select optimal flight paths, whose use would lower costs, improve safety, and help accommodate future growth in air traffic through the more efficient use of airspace and airport resources. Implementing this new air traffic management system will require FAA to introduce new technologies[7] and procedures. FAA plans to

[6]The ATC system comprises a vast network of radars; automated data processing, navigation, and communication equipment; and air traffic control facilities. It is through the ATC system that FAA controls takeoffs and landings and manages the flow of traffic between airports. Other components of the NAS include airports or landing areas; aeronautical charts, information, and services; rules, regulations, and procedures; technical information; and personnel and material.

[7]Many of these technologies, such as the User Request Evaluation Tool (conflict probe) and Single Center Traffic Management Advisor and Passive Final Approach Spacing Tool (traffic sequencing tools) are currently in various stages of development.

test other new technologies and procedures through an initiative called Flight 2000 (now the Free Flight Operational Enhancement Program).[8]

National Airspace System/Air Traffic Control System

FAA's air traffic controllers direct aircraft through the NAS. Automated information-processing and display, communication, navigation, surveillance, and weather equipment allow air traffic controllers to see the location of aircraft, aircraft flight plans, and prevailing weather conditions, as well as to communicate with pilots. FAA controllers are primarily located in three types of facilities: air traffic control towers, terminal area facilities, and en route centers. The functions of each type of facility are described below.

- Airport towers control the flow of aircraft—before landing, on the ground, and after take-off—within 5 nautical miles of the airport and up to 3,000 feet above the airport. A combination of technological and visual surveillance is used by air traffic controllers to direct departures and approaches, as well as to communicate instructions and weather-related information to pilots.
- Terminal area facilities—known as Terminal Radar Approach Control (TRACON) facilities—sequence and separate aircraft as they approach and leave busy airports, beginning about 5 nautical miles and extending to about 50 nautical miles from the airport and up to 10,000 feet above the ground.
- Air Route Traffic Control Centers (ARTCC)—or en route centers—control planes in transit over the continental United States and during approaches to some airports. Planes are controlled through regions of airspace by en route centers responsible for the regions. Control is passed from one en route center to another as a plane moves across a region until it reaches TRACON airspace. Most of the en route centers' controlled airspace extends above 18,000 feet for commercial aircraft. En route centers also handle lower altitudes when dealing directly with a tower or after agreeing with a terminal facility. Aircraft over the ocean are handled by en route centers in Oakland and New York. Beyond the radars' sight, controllers must rely on periodic radio communications through a third party—Aeronautical Radio Incorporated (ARINC), a private organization funded by the airlines and FAA to operate radio stations—to determine aircraft locations.

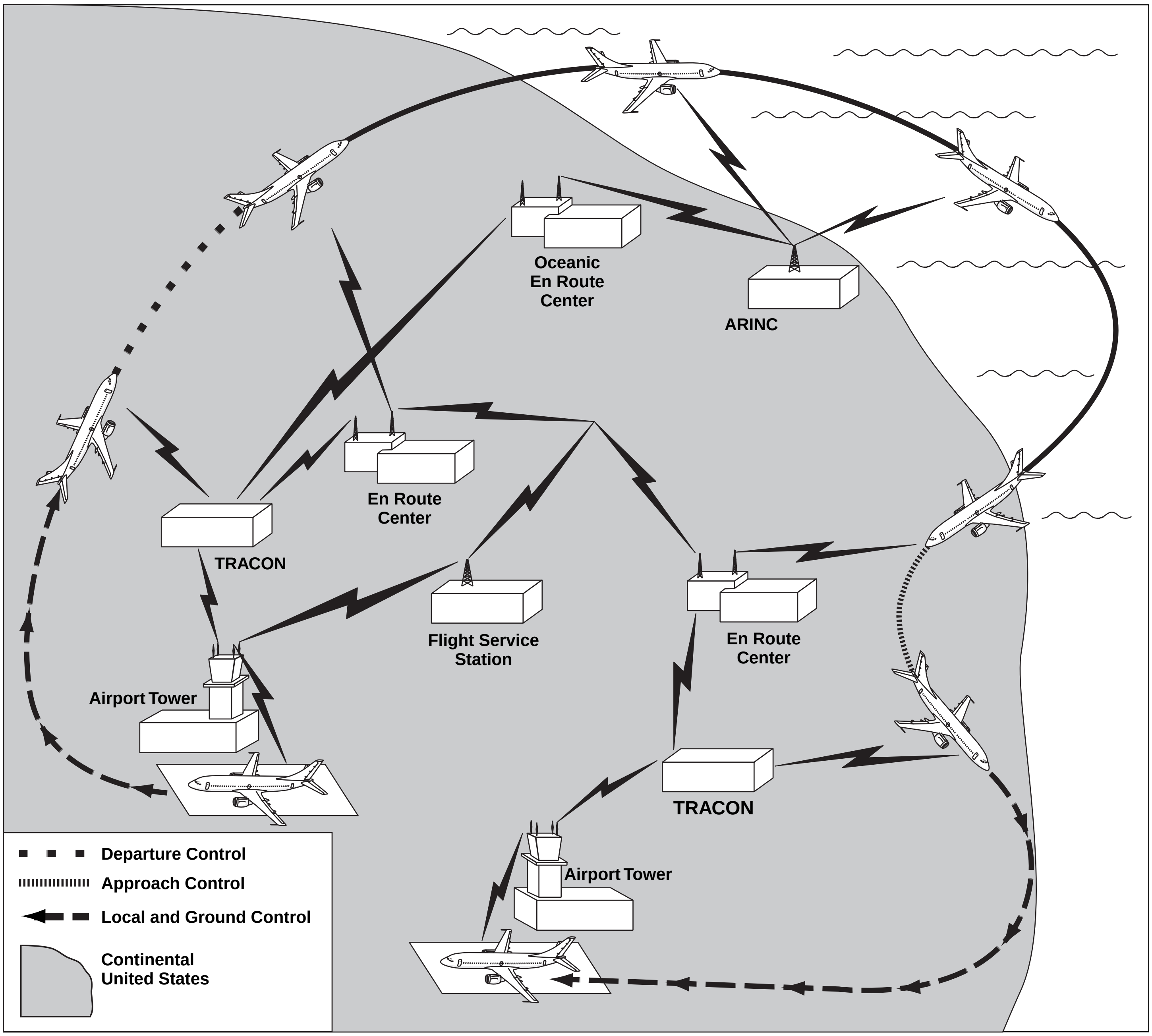
[8] Among other capabilities, this demonstration will use (1) the Flight Information Service to provide enhanced weather information and the status of Special Use Airspace, (2) Automatic Dependent Surveillance-Broadcast in a number of ways to improve the efficiency of ground and air operations, and (3) the Traffic Information Service to improve pilots' awareness of surrounding traffic and the efficiency of operations in low-visibility conditions.

- Flight Service Stations provide weather and flight plan services, primarily for general aviation pilots.[9]

See figure 1.1 for a visual summary of air traffic control over the continental United States and oceans.

[9]Our report focuses on free flight technologies that will be implemented primarily in the tower, terminal, and en route environments. Therefore, we do not include further discussion of Flight Service Stations.

Figure 1.1: Summary of Air Traffic Control Over the Continental United States and Oceans



FAA will continue to operate en route, terminal, and tower facilities under the new air traffic management system; controllers in these facilities will be able to manage flight operations more collaboratively through the use of new decision support tools. For example, two new traffic management tools will allow en route and terminal controllers to better sequence aircraft as they move into the terminal environment—potentially increasing the system's safety and efficiency.[10]

What Is Free Flight?

Free flight is a new way of managing air traffic that is designed to enhance the safety, capacity, and efficiency of the NAS. Under this new management system, air traffic control is expected to move gradually from a highly structured system based on elaborate rules and procedures to a more flexible system that allows pilots, within limits, to change their route, speed, and altitude, notifying the air traffic controller of the new route. In contrast, under the present system, while flight plans are developed in conjunction with air traffic control personnel, aircraft are required to fly along specific routes with minimal deviation. When deviations from designated routes are allowed—to, for example, avoid severe weather—they must be pre-approved by an air traffic controller. Under free flight, despite the availability of flexibilities to pilots, the ultimate decision-making authority for air traffic operations will continue to reside with controllers.

While FAA and the aviation community have recently increased their efforts to implement free flight, the concept of free flight—allowing pilots to fly more optimal routes—is not new. In fact, the idea has been around for decades. With the development of navigation technology in the 1970s that allowed aircraft to fly directly from origin to destination without following fixed air routes (highways in the sky), the possibility of providing pilots with flexibility in choosing routes became viable. However, until recently, movement to develop the procedures and decision support systems needed to fully use this type of point-to-point navigation has been slow. In the last several years, because of the need to meet demands for increasing the system's capacity and efficiency, FAA and aviation system users and their major trade organizations, representatives of air traffic control personnel, equipment manufacturers, the Department of Defense (DOD),

[10]Under Free Flight Phase 1, FAA will use two Center TRACON Automation System (CTAS) tools: Traffic Management Advisor (TMA) and Final Approach Spacing Tool (FAST). TMA will provide en route/terminal controllers with automation tools to schedule aircraft to enter or depart from airspace that is between 5 and 50 miles from the airport. FAST will provide runway assignment and sequence numbers to air traffic controllers. FAST operates in conjunction with TMA to provide integrated traffic management system decision support tools. En route and terminal traffic management coordinators will use TMA, and terminal radar controllers will use FAST.

and others (collectively referred to as stakeholders) have been working on plans to accelerate the implementation of free flight.

To enable this new system of air traffic management, FAA plans to introduce a range of new technologies and procedures that will give pilots and controllers more precise information about the location of aircraft. This information will eventually allow for the distances between aircraft to be safely reduced—in turn, allowing more aircraft to operate in the system. For example, a new tool planned for use primarily in the en route environment will give controllers better information about the location of aircraft so that they can detect and resolve potential conflicts sooner than they can using current technology. Similarly, pilots will have more precise information about the location of their aircraft in relation to other aircraft. The use of these technologies will help to improve the system's safety and capacity. While free flight will provide pilots with more flexibility, different situations will dictate its use. For instance, in clear, uncrowded skies, pilots may be able to use free flight fully, but some restrictions may be necessary during bad weather or in highly congested areas.

FAA Developed a Definition of Free Flight With Stakeholders

Developing an integrated, modernized air traffic control system requires that government and stakeholders reach consensus on or hold complementary views of what they want to achieve and how they want to achieve it. In an effort to gain consensus, in 1994, FAA asked RTCA to form a select committee of government and industry participants to study free flight. This group included representatives from general aviation, the airline industry, pilots' and air traffic controllers' unions, and government. To continue the work of this select committee, RTCA formed a task force with similar representation to develop a strategy for implementing free flight. As part of its work, the task force defined free flight as

> "a safe and efficient flight operating capability under instrument flight rules in which the operators have the freedom to select their path and speed in real time. Air traffic restrictions are only imposed to ensure separation, to preclude exceeding airport capacity, to prevent unauthorized flight through Special Use Airspace (SUA),[11] and to ensure safety of flight. Restrictions are limited in extent and duration to correct the identified problem. Any activity which removes restrictions represents a move toward Free Flight."

Stakeholders generally agree with the above broad concept—especially the idea that any activity that removes restrictions represents a move

[11]In general, SUA is airspace designated for use by DOD and other federal agencies to carry out special research, testing, training, and other activities. Nonparticipating aircraft—both civil and military—may be restricted from flying into such areas.

toward free flight. However, because users have different priorities based on their use of the system, they have different ideas about how best to implement this concept.

Free Flight Will Affect a Wide Range of Users in All Operating Environments

RTCA has found that the implementation of free flight will affect a wide range of users—from part-time pilots to major airlines—depending on the operating environment. For example, in the en route environment, users will be allowed to fly more optimal routes between airports, thus saving time and money. In addition, under certain conditions, these users may be allowed to safely reduce the distance between themselves and other aircraft. Similarly, in airspace between 5 and 50 miles from the airport, the improved sequencing of traffic for approaches and landings will provide the potential for users to operate more efficiently than under the present system. Improved sequencing is expected to increase the number of aircraft that can safely operate in this environment at a given time. In addition, improved information sharing between pilots and controllers on the location of aircraft on an airport's surface, for example, is expected to allow for better use of the airport's surface capacity (such as runways and gates). Efficient use of this limited capacity is key to allowing users to maximize the benefits of operations under free flight.

Objectives, Scope, and Methodology

In light of FAA's current efforts to replace its aging infrastructure and keep pace with increasing demands for air traffic services through the new system of air traffic management known as free flight, the chairmen and ranking minority members of the Senate Committee on Commerce, Science, and Transportation and its Subcommittee on Aviation asked us to monitor the implementation of FAA's efforts and provide them with a series of reports. This initial report provides (1) an overview of FAA's progress to date in implementing free flight, including Flight 2000 (now the Free Flight Operational Enhancement Program), and (2) the views of the aviation community and FAA on the challenges that must be met to implement free flight cost-effectively.

To address the first objective, we met with key FAA officials responsible for the programs involved in the agency's free flight implementation efforts to gain a better understanding of how FAA is coordinating the agencywide and program-specific elements of free flight. The issues discussed with these officials included (1) the definition/philosophy of free flight; (2) details on key agencywide and program-specific initiatives, such as Flight 2000 (now the Free Flight Operational Enhancement Program); and (3) the status of the agency's efforts to develop, deploy, and integrate new technologies; mitigate risk; develop metrics; collaborate with other FAA program offices and stakeholders; improve certification procedures; develop cost/benefit analyses; and gain buy-in to free flight implementation efforts among FAA staff and the aviation community. We discussed these same issues with a broad range of stakeholders to get their views on the agency's progress to date in implementing free flight. These stakeholders, who have collaborated with FAA to implement free flight, included representatives of RTCA, trade organizations (such as the Air Transport Association, Airports Council International, Regional Airline Association, National Business Aircraft Association, and Aircraft Owners and Pilots Association), employee unions (including the National Air Traffic Controllers Association, Air Line Pilots Association, and Professional Airways Systems Specialists), DOD, academic institutions (Massachusetts Institute of Technology (MIT) and University of Illinois, Champaign) and research and contracting organizations (MIT Lincoln Laboratory, Department of Transportation/Volpe Center, National Aeronautics and Space Administration, and MITRE), major airlines, cargo carriers, and aircraft and avionics manufacturers.

In addressing the second objective, we asked the same FAA officials and stakeholders to identify the key challenges that must be met for free flight to be implemented cost-effectively.

As part of our review for both objectives, we researched the current literature and reviewed relevant FAA documents (such as the NAS architecture and operational concept, capital investment plan, and cost and schedule information for key projects). In addition, we obtained and reviewed documentation from stakeholders in support of their positions on outstanding issues related to implementing free flight.

We provided copies of a draft of this report to FAA for its review and comment. We met with FAA officials, including the Director, Program Office, Free Flight Phase 1, and the Acting Program Directors for Flight 2000 and Architecture and Systems Engineering, who generally agreed with the contents of the report and provided clarifying comments, which we incorporated as appropriate.

We conducted our audit work from November 1997 through August 1998 in accordance with generally accepted government auditing standards.

FAA's Efforts to Implement Free Flight

Under its air traffic control modernization program, FAA is upgrading its facilities and equipment—including replacing aging infrastructure, such as controllers' workstations and the Host computer—and ensuring that its systems comply with Year 2000 requirements.[12] While these efforts are not part of free flight, they will provide the infrastructure that is critical for its implementation. To define free flight and develop recommendations, associated initiatives, and time frames for its implementation, FAA has worked with stakeholders under the leadership of RTCA—a nonprofit organization that serves as an advisor to FAA. As of July 1998, 1 of 44 recommendations had been completed, and substantial progress has been made in implementing many of the initiatives that fall under the remaining recommendations.

While working to implement the 44 recommendations, FAA and stakeholders agreed on the need to focus their efforts on deploying technologies designed to provide early benefits to users. These efforts led to consensus on a phased approach to implementing free flight—beginning with Free Flight Phase 1—including the core technologies to be used and the locations where the technologies will be deployed under this first phase, scheduled to be implemented by 2002. FAA has been working with stakeholders to resolve differences among them and to better define its planned limited demonstration, known as Flight 2000 (now the Free Flight Operational Enhancement Program), which is designed to identify and mitigate the risks associated with using free-flight-related communication, navigation, and surveillance technologies and associated procedures. As a result of these collaborative efforts, FAA and stakeholders—through RTCA—have agreed to a general roadmap for a restructured demonstration to be conducted in fiscal years 1999-2004. However, unresolved issues remain, including the need to secure funding and develop additional plans.

Progress Toward Implementing Free Flight Recommendations

In its October 1995 report, RTCA discussed the benefits of free flight and included recommendations and time frames for users and FAA to consider for implementing free flight.[13] These recommendations, many of which have several initiatives, emphasized, among other things, the (1) consideration of human factors during all phases of developing free

[12] The Host computer is the centerpiece information-processing system in FAA's en route centers. It processes flight, radar, and display data for use by controllers. When FAA restructured the centerpiece of its modernization program—the Advanced Automation System—in 1994, it canceled the segment that included the Host replacement. FAA is currently acquiring the Host and Oceanic Computer System Replacement to overcome hardware supportability problems and resolve Year 2000 date requirements with the Host computer.

[13] Final Report of RTCA Task Force 3: Free Flight Implementation, RTCA (Oct. 1995).

flight, (2) use of streamlined methods/procedures for system certification, and (3) expansion of the National Route Program. The vast majority of these recommendations (35 of 44) were to be completed in the near term (1995 through 1997), 6 are focused on the midterm (1998 through 2000), and 3 are to be completed in the far term (2001 and beyond). See appendix I for a list of these recommendations.

Since late 1995, FAA and stakeholders have been working on various free flight recommendations and many associated initiatives and, in August 1996, agreed on an action plan to guide their implementation.[14] According to FAA, through July 1998, they have fully implemented only 1 of the 35 near-term recommendations—to incorporate airline schedule updates, such as delays and cancellations, into FAA's Traffic Flow Management system to help it reduce unnecessary restrictions and delays imposed on airline operations. However, FAA and stakeholders have made substantial progress in implementing many of the initiatives under the near-term recommendations. For example, as outlined under a recommendation to extend the benefits of data exchange, FAA has deployed digital pre-departure clearances at 57 sites, which provide pilots with departure information via digital cockpit displays and reduce the need for voice messages. In addition, 49 of these sites have Digital Automatic Terminal Information Service, which provides information about current weather, airport, and facility conditions around the world. Digital communications provide an advantage over voice communications by helping to relieve congested voice frequencies and reduce the number of operational errors that are caused directly or indirectly by miscommunication. Under another recommendation, FAA is working with stakeholders through an RTCA task force to find ways to reduce the time and cost associated with the agency's process for approving new technologies for flight operations. To address another recommendation, FAA has deployed a technology, on a limited basis, for controllers' use that is expected to improve the sequencing of air traffic as aircraft enter, leave, and operate within terminal airspace.

Work is under way on six midterm and three far-term recommendations and their associated initiatives. For the most part, these recommendations focus on incremental improvements to the core technologies that are being deployed under Free Flight Phase 1 and those planned for deployment under Flight 2000 (now the Free Flight Operational Enhancement Program). For example, in the midterm, FAA has begun to modify controllers' workstations and supporting computer equipment to accept, process, and display data received from satellites. In addition,

[14]Free Flight Action Plan, RTCA (Aug. 1996).

under a far-term recommendation, FAA is studying the feasibility of using satellite-based information to provide more precise information for landing during periods of limited visibility.

FAA also noted that while it was in the early stages of planning for the implementation of free flight, it took steps to maximize the air traffic control system's capacity and efficiency by extending flexibilities to users—to select and fly more efficient flight paths when operating in designated altitudes/areas—through programs such as the National Route Program (NRP).

Existing Programs Extend Some Flexibility to Users

FAA has two early efforts under way to allow users (under certain conditions) to select routes and procedures that will save them time and money—NRP and the Future Air Navigation System (FANS). Established in 1990, NRP is intended to conserve fuel by allowing users to select preferred or direct routes. FAA estimates that NRP saves the aviation industry over $40 million annually. These savings are realized, in part, because pilots are allowed to take advantage of favorable winds or minimize the effects of unfavorable winds, thereby reducing fuel consumption. Initially allowed only at higher altitudes, the program has been expanded to include operations down to 29,000 feet. FAA is also working to decrease, where appropriate, the present restriction that flights must be 200 miles from their point of departure before they can participate and must end their participation 200 miles prior to landing.

FANS uses new technologies and procedures that enhance communication between pilots and air traffic controllers and provide more precise information on the position of aircraft—allowing for improvements in air navigation safety and in the ability of air traffic controllers to monitor flights. Used primarily over the oceans and in remote areas normally out of the range of ground-based navigation aids, FANS uses digital communication more than voice communication to exchange information such as an aircraft's location, speed, and altitude. Although FANS is gradually being implemented in many regions and countries, the aviation community believes that for its full operational benefits (such as time and fuel savings) to be realized, air traffic control procedures need to be modified to shorten the distance currently required between aircraft. They also contend that FAA needs to deploy the promised hardware and software (Automatic Dependent Surveillance or ADS[15]) infrastructure for

[15]ADS is a surveillance technology that will provide more accurate position reports for use by controllers and pilots to safely reduce distances between aircraft and make more efficient use of airspace. ADS would permit controllers to see traffic in places previously outside of radar coverage.

FANS in facilities that support airline operations primarily over the Pacific Ocean in order for these benefits to be realized.

FAA's Efforts to Reach Consensus Lead to Free Flight Phase 1

In November 1997, the FAA Administrator began an outreach effort with the aviation community to build consensus on and seek commitment to the future direction of the agency's modernization program. As part of this effort, she formed a task force of senior transportation officials, union leaders, and executives and experts from the aviation community to assess the agency's modernization program—including the NAS architecture—and develop a plan for moving forward.[16] Much as we found in reviewing the system's logical architecture in February 1997, the task force found that the architecture under development appropriately built on the concept of operations for the NAS and identified the programs necessary to meet users' needs.[17] However, the task force found that the architecture was insufficient because of issues associated with cost, risk, and lack of commitment from users.

In response, the task force recommended a phased approach that would cost less, focus more on providing near-term benefits to users, and modernize the NAS incrementally. Many of the initiatives identified under the near- and midterm recommendations will be included under this phased approach because these initiatives are expected to provide early benefits for users. A central tenet of this approach is the "build a little, test a little" concept of technology development and deployment—intended to limit efforts to a manageable scope, identify and mitigate risks, and deploy technologies before the system is fully mature when they can immediately improve the system's safety, efficiency, and/or capacity. Such a phased approach to implementing free flight was designed to help the agency avoid repeating past modernization problems associated with overly ambitious cost, schedule, and performance goals and to restore users' faith in its ability to deliver on its promises.

As a first step toward the phased implementation of free flight, FAA—in coordination with stakeholders—outlined a plan for Free Flight Phase 1 in

[16]This group is known as the Administrator's NAS Modernization Task Force.

[17]In February 1997, we identified shortcomings in two main areas: FAA's systems architecture lacked a technical architecture and an effective enforcement mechanism. A technical architecture details the specific information technology and communication standards and approaches that will be used to build the systems, including those that address critical hardware, software, communication, data management, security, and performance characteristics. It ensures that the systems interoperate effectively and efficiently. FAA is developing a technical architecture as we recommended. See Air Traffic Control: Complete and Enforced Architecture Needed for FAA Systems Modernization (GAO/AIMD-97-30, Feb. 3, 1997).

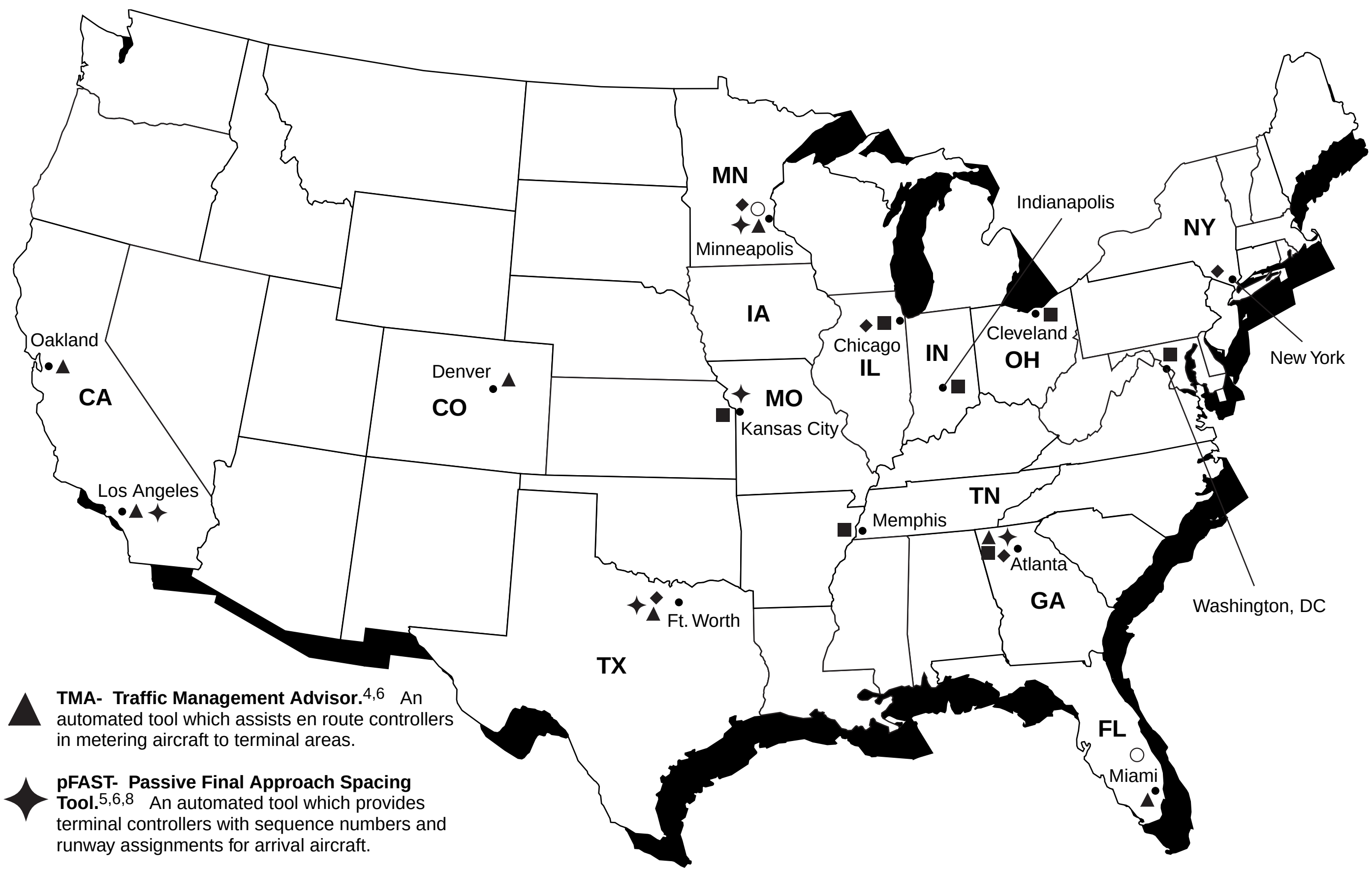
early 1998. This plan is expected to be implemented by 2002. As currently envisioned, Free Flight Phase 1 calls for the expedited deployment of certain NAS technologies. The technologies—which are at various stages of development and will be further refined and tested are the (1) Controller Pilot Data Link Communications (CPDLC) Build 1, (2) User Request Evaluation Tool (URET), (3) Single Center Traffic Management Advisor (TMA), (4) Collaborative Decision Making (CDM), (5) Surface Movement Advisor (SMA), and (6) Passive Final Approach Spacing Tool (pFAST). In general, these technologies are expected to provide tools for controllers that will help to increase the safety and capacity of the air traffic control system and benefit users through savings on fuel and crew costs. For example, FAA and many stakeholders believe that TMA and pFAST should improve controllers' ability to more efficiently sequence traffic to improve its flow in crowded terminal airspace.

Similarly, they believe the URET conflict probe will improve controllers' ability to detect and resolve potential conflicts sooner than present technology allows. However, in June 1998, the air traffic controllers' union at one of the two en route centers where URET is being tested asked that its use be terminated until several concerns about its use in the current environment can be resolved.[18] Termination did not occur at this facility, and the issue has been elevated to the regional level within FAA for resolution. See appendix II for a summary of the status of the recommendations related to Free Flight Phase 1.

The aviation community generally agrees on the core technologies for Free Flight Phase 1 and on the locations proposed for deploying and testing these technologies. See figure 2.1 for these sites. In addition, FAA is currently developing a Free Flight Phase 1 plan that will provide more details on implementing the program and recently appointed a program manager to lead this effort.

[18]Controllers at the Indianapolis en route center are concerned that the use of URET has become a "distraction" when they switch from using URET (without flight strips) to standard operating procedures (with flight strips) and that this transition can impair their awareness of sector operations. In addition, controllers maintain that using URET has increased their workload by requiring them to enter data twice—into both URET and the Host computer.

Figure 2.1: Proposed Locations for Deploying and Testing Free Flight Phase 1 Technologies[1,2,3]



▲ **TMA- Traffic Management Advisor.**[4,6] An automated tool which assists en route controllers in metering aircraft to terminal areas.

✦ **pFAST- Passive Final Approach Spacing Tool.**[5,6,8] An automated tool which provides terminal controllers with sequence numbers and runway assignments for arrival aircraft.

■ **URET- User Request Evaluation Tool.** An automated tool which assists en route controllers in identifying conflicts up to 20 minutes in advance of their occurrence.

○ **CPDLC-1- Controller Pilot Data Link Communications, Build 1.**[9] A two-way data link communication between the ground controller and pilot using predefined messages.

◆ **SMA- Surface Movement Advisor.**[7] A system which facilitates sharing of dynamic information among airspace users, airport operators and air traffic controllers to enhance efficiency of surface movement.

1 Operational by 1998-2002.
2 Assumes no impact on other programs.
3 Risks need to be identified and a risk mitigation plan established and implemented in coordination with RTCA.
4 In 1998, launch R&D program to develop tools to expedite arrivals in complex airspace–at PHL (Philadelphia International Airport)–(outside funding scope of FFP1).
5 By June 1998, determine feasibility of implementing stand-alone pFAST without multi-center TMA, and implement accordingly (outside funding scope of FFP1).
6 Begin development after completion of current airspace review and design.
7 Functionality different from SMA at Atlanta.
8 Stand-alone pFAST without single-center TMA.
9 It has not yet been determined whether the selected site will be Minneapolis or Miami. A final decision by FAA is expected to be made in early 1999.

Note: CDM is another Free Flight Phase 1 technology. It provides a real-time exchange of information on flight plans and system constraints to assist airline and air traffic control personnel in making decisions about NAS resources. As such, its use is not associated with specific locations.

As a companion effort, FAA has charged RTCA with responsibility for building consensus within the aviation community on how best to revise the vision for modernization (operational concept) and to develop the blueprint (architecture/framework) for carrying out the modernization. It is critical that the vision for modernization and the blueprint for implementing this vision be tightly integrated to help ensure that free flight activities are coordinated and working toward common goals.

Plans for Free Flight Demonstration Still Under Development

In January 1997, Vice President Gore announced an initiative—Flight 2000—to demonstrate and validate the use of navigation capabilities to support free flight. FAA then expanded Flight 2000 to include communication and surveillance technologies. FAA viewed Flight 2000 as an exercise for testing free flight technologies and procedures in an environment where safety hazards could be minimized. FAA expected the Flight 2000 program to validate the benefits of free flight, evaluate transition issues, and streamline the agency's procedures for ensuring that new equipment is safe for its intended use.

Proposed primarily for Alaska and Hawaii, Flight 2000 would have tested communication, navigation, and surveillance technologies, such as the Global Positioning System (GPS) and its augmentations, the Wide Area Augmentation System (WAAS) and the Local Area Augmentation System (LAAS);[19] Controller Pilot Data Link Communications (CPDLC); and ADS-B technology. FAA initially selected these locations because they offer a controlled environment with a limited fleet, which includes all classes of users, all categories of airspace, and wide ranges of weather conditions and terrain. However, many in the aviation community questioned whether the lessons learned in Alaska and Hawaii would apply to operations in the continental United States. At their urging, FAA agreed to add at least one site within the continental United States to the Flight 2000 demonstration.

[19]GPS is a network of 24 satellites that transmit radio signals that allow properly equipped users—in the air, on land, and at sea—to calculate the time, their positions and speed, and weather conditions. However, as currently designed for military purposes, GPS can provide only limited service to civil aviation. FAA is developing WAAS and LAAS to enhance GPS by correcting signal errors, increasing satellite coverage, and providing timely warnings to users of malfunctions to allow GPS to satisfy FAA's requirements for integrity, accuracy, and availability. GPS needs to satisfy these requirements if it is to become a primary means of navigation for free flight operations.

Collaborative efforts between FAA and stakeholders on Flight 2000—through RTCA—have led to broad consensus on a general roadmap for restructuring this demonstration program, including four criteria for selecting the candidate operational capabilities to be demonstrated. In general, under these criteria (1) industry and FAA must address all aspects of modernization to be successful in moving toward free flight; (2) expected benefits are the major reason for implementing a given capability; (3) the capability does not interfere with or slow down any near-term activities; and (4) the risks associated with operational capabilities that require integrating multiple communication, navigation, and surveillance technologies should be addressed.

Using these criteria, FAA and stakeholders reviewed over 70 potential operational capabilities and selected 9 of them. They also recommended demonstration locations in the Ohio Valley and Alaska. (See app. III for a description of these capabilities and the expected operational benefits.) For example, under this proposal, FAA would provide more accurate weather information to pilots and controllers to improve safety and potentially reduce flight times. In addition, FAA would improve airport surface navigation capabilities by providing pilots (and operators of other surface vehicles) with moving maps that display traffic in low-visibility conditions. FAA and stakeholders also recommended that the program be renamed the "Free Flight Operational Enhancement Program." Stakeholders and FAA recognize that more detailed planning is needed—to identify risk-mitigation activities, select the final site, and estimate costs, schedules, and the number of required aircraft—and that this planning will require close coordination between FAA and industry to ensure that plans are consistent with stated operational capabilities and are achievable by FAA and users. FAA is currently considering the proposed RTCA roadmap for the restructured Flight 2000 demonstration and expects to reach a decision in the fall of 1998. If approved as scheduled, a detailed plan is expected by the end of 1998.

FAA and the Aviation Community Face Many Challenges in Implementing Free Flight Cost-Effectively

FAA's plan to implement free flight through an evolutionary (phased) approach is generally consistent with past recommendations that we and others have made on the need for FAA to achieve a more gradual, integrated, and cost-effective approach to managing its modernization programs. However, FAA and stakeholders recognize that significant challenges must be addressed if the move to free flight—including Free Flight Phase 1 and Flight 2000 (now the Free Flight Operational Enhancement Program) is to succeed. While FAA must address many of the challenges, stakeholders recognize that, as partners, they must assist the agency. The challenges for FAA are to (1) provide effective leadership and management of modernization efforts—including cross-program communication and coordination; (2) develop plans—in collaboration with the aviation community—that are sufficiently detailed to move forward with the implementation of free flight—including the identification of clear goals and measures for tracking the progress of the modernization efforts; (3) address outstanding issues related to the development and deployment of technology—such as the need to improve the agency's process for ensuring that new equipment is safe for its intended use and methods for considering human factors; and (4) address other issues, such as the need for FAA to coordinate its modernization and free flight efforts with those of the international community and integrate free flight technologies.

Effective Management Is the Key to Implementing Free Flight Successfully

FAA and stakeholders identified a number of managerial issues that will need to be addressed if free flight is to be implemented successfully. For example, (1) provide strong senior leadership to guide the implementation of free flight both within and outside the agency and (2) implement an evolutionary rather than a revolutionary approach to modernization. Successfully addressing these issues will help the agency effectively implement free flight.

FAA Needs to Exercise Strong Leadership

Some FAA officials and stakeholders said that the agency will need to provide strong leadership both inside the agency and within the aviation community for free flight to be implemented successfully. For example, some FAA officials and stakeholders said that the agency will need to improve the effectiveness of its internal operations by encouraging communication and cooperation between the various program offices responsible for its free flight efforts. Additionally, some FAA officials and stakeholders said that the agency will need to continue efforts to build consensus among the aviation community and gain its commitment to the direction of the agency's plans for modernization.

Effective Leadership Is Needed Within FAA

Some FAA officials and stakeholders told us that improvements in communication and coordination across FAA program offices are needed to implement free flight successfully. For example, one FAA official told us that the primary challenge facing the agency in its efforts to implement free flight is developing effective communication and coordination across program lines. Some stakeholders shared this concern, observing that the various program offices within FAA do not communicate well or effectively coordinate their activities. Thus, according to some within FAA and stakeholders, despite the agency's move to using cross-functional, integrated product teams[20] to improve accountability and coordination across FAA, these teams have become insular and some team members tend to be motivated primarily by the priorities and management of the offices that they represent rather than the goals of a given team. One stakeholder stressed that the effectiveness of these teams has also been limited by (1) inadequate training of members on how to operate a team and (2) the fact that these teams are given responsibility for projects without the commensurate authority they need to carry out their responsibilities. Some stakeholders also noted that the agency has not made a number of decisions about modernization because of ongoing disagreements among various program offices over how best to proceed with its various components, such as the selection of new free flight technologies for communicating information digitally rather than by voice.

The concerns cited above are consistent with our prior work on FAA's culture as it affects acquisition management.[21] In particular, we found that the agency has previously had difficulty communicating and coordinating effectively across traditional program lines. In addition, we learned from some FAA staff and functional managers that FAA has encountered resistance to the integrated product team concept and these teams' operations. As we reported, one major factor impeding coordination has been FAA's organization into different divisions whose "stovepipes," or upward lines of authority and communication, are separate and distinct. Because FAA's operational divisions are based on a functional specialty,

[20]Integrated product teams are designed to be cross-functional teams that are responsible for developing or procuring new equipment. The goals of these teams are to improve accountability and coordination and infuse a more strategic, mission-oriented focus into the acquisition process. Team members include contractors, FAA's engineering division, and the FAA divisions that operate and maintain air traffic control equipment.

[21]Aviation Acquisition: A Comprehensive Strategy Is Needed for Cultural Change at FAA (GAO/RCED-96-159, Aug. 22, 1996).

such as engineering, air traffic control, or equipment maintenance, getting the employees in these units to work together has been difficult. Internal and external studies have found that the operations and development sides of FAA have not forged effective partnerships.

To its credit, FAA is currently attempting to improve cross-agency communication and coordination by developing incentives for staff to work toward the agency's goals and priorities. Plans are also under way to develop contracts with each integrated product team to hold its members accountable for developing and deploying a given operational capability. According to FAA officials, these contracts are intended to improve accountability for delivering technologies; in the past, such accountability has not been clearly assigned. In addition, efforts are under way to work with the aviation community to resolve disagreements that have persisted among FAA program offices, such as how to proceed with the use of digital communication.

FAA Needs to Exercise Strong Leadership in Delivering on Its Commitments to the Aviation Community

While stakeholders generally applaud FAA's efforts to build consensus among stakeholders, some believe that the agency must be prepared to exercise strong leadership by (1) making difficult decisions after weighing stakeholders' competing priorities, (2) holding to these decisions even amidst new and conflicting opinions about the value of one course of action over another, and (3) delivering on its commitments. Some stakeholders said they were particularly frustrated when, after announcing a planned course of action, FAA later delayed its implementation or retracted it and moved in a different direction. Some stakeholders told us that such indecision makes it very difficult for them to make plans for the future—such as determining investments for avionics upgrades—and further erodes their confidence in the agency's ability to manage modernization programs and provide leadership to the aviation community. For example, several stakeholders cited FAA's failure to deliver the ground-based infrastructure, needed for users to accrue benefits from equipping with new technologies under the Future Air Navigation System program, as a warning signal to them to proceed cautiously, since the agency may not deliver on its promises. In particular, users are concerned that if they invest in new technologies, they will not realize benefits in a timely manner to offset these investments.

FAA Needs to Effectively Implement an Evolutionary Approach to Technology Development and Deployment

Some stakeholders believe that for FAA to successfully implement free flight, it must demonstrate that it can effectively manage its air traffic control modernization programs and deliver promised capabilities. To do so, FAA will need to implement an evolutionary approach to technology development and deployment. According to FAA, under such an approach, it will limit the scope of project segments so that it can deploy, test, evaluate, and refine a given technology until it obtains the desired capabilities. One stakeholder familiar with this approach emphasized the importance for FAA, in implementing it, of (1) assessing risks, (2) developing metrics, (3) limiting the scope of each phase of development, (4) evaluating progress before moving forward with the next phase of development, and (5) retraining staff. These steps would be applied to each cycle of the development process to help ensure that each completed iteration results in enhanced capabilities and moves a given technology closer to its desired level of maturity. FAA agreed that each of these steps will be important for successfully implementing this approach.

FAA has not yet developed detailed plans for implementing this approach; however, in concept, it is consistent with our past recommendations that the agency avoid taking on unrealistic cost, schedule, and performance goals. For example, the recently developed plans for revising the Flight 2000 demonstration recommend an incremental approach, under which operational capabilities will be introduced over time into planned field demonstration sites. FAA and users expect such an approach will allow them to achieve success by taking smaller, less risky, more manageable steps. Some stakeholders told us that although they are encouraged by FAA's efforts to date, they are taking a wait-and-see attitude as to whether the agency can effectively implement this approach to technology development and deployment.

Clear Goals and Measures and Sufficiently Detailed Plans Are Necessary for Implementing Free Flight

FAA and stakeholders have identified a wide range of concerns that need to be addressed to help ensure that efforts to implement free flight are sufficiently well developed as the agency moves forward with related modernization activities. These concerns include, among others, the need for (1) FAA—in collaboration with stakeholders—to develop clear goals and objectives for what it intends to achieve, as well as a measurement system for tracking progress, and (2) FAA and stakeholders to develop detailed plans that will allow for the cost-effective implementation of free flight.

Clear Goals and a Measurement System Are Important to the Successful Implementation of Free Flight

While FAA and stakeholders agree on the basic premise of moving toward free flight and the agency's initial plans to deploy technologies under its first phase, stakeholders told us that FAA—in collaboration with them—needs to establish clear goals and objectives for what it intends to achieve for this and other free flight efforts and a measurement system for tracking progress. For example, a representative of a major systems contractor believes that it is critical for FAA to clearly articulate its vision and goals for where it intends to go with free flight so that the future direction is clear to everyone involved. A representative of a major airframe manufacturer agreed with this position and added that the agency should focus on what the system will look like 10 to 20 years from now. In this representative's view, once this is determined, then the agency and stakeholders should begin discussing the technologies and procedures that will be needed for the future system.

In addition, the representative of the major airframe manufacturer stressed that FAA is developing the NAS architecture from the bottom up—merely inserting technologies into the air traffic control system rather than focusing on how the entire system needs to change. According to this representative, FAA is "putting the cart before the horse" by adhering to a replacement technology philosophy—"keep doing what we are doing but with automation support." The real challenge is to rethink the operation first, including the roles of people and automation, and then decide which technologies and procedures to use. Some FAA officials and stakeholders stressed that this approach will require long-range research programs that currently do not receive enough priority in the agency's plans because of resource constraints.

As for a measurement system, some FAA officials and stakeholders said that before developing performance measurements, the agency will need to develop baseline data to use as a benchmark for tracking its progress in implementing free flight. These stakeholders noted that without a concrete sense of where the agency is now in terms of capacity, efficiency, and other measures, progress is difficult to measure.

Calls for these types of measures are consistent with the requirements of the Government Performance and Results Act of 1993, which emphasizes the need for agencies to clearly define their missions, establish long-term strategic goals, and measure their performance against the goals they have set. With firm baseline data, FAA will be in a better position to develop measures to track its progress as it proceeds to implement free flight. Some FAA officials and stakeholders acknowledged that developing such measurements is difficult, and as part of Free Flight Phase 1, the aviation community (airlines, DOD, and other stakeholders) will provide FAA with information to establish baseline measures. FAA officials also said that supplemental performance data will be needed to track progress. In addition, FAA and stakeholders have proposed measures for tracking progress that will be used in conjunction with the revised Flight 2000 demonstration.

Performance measures are also required under FAA's new acquisition management system. The Congress directed FAA in 1995 to develop this new system to improve the timeliness and cost-effectiveness of the agency's acquisition of equipment.[22] The new system includes requirements to improve the agency's management of modernization programs, including (1) identifying critical shortfalls in the NAS' capability and technologies that could be used, among other things, to improve the NAS' safety and efficiency; (2) establishing critical performance parameters and benefits that a program must achieve and setting boundaries for cost and schedule; and (3) developing metrics of critical performance measures, such as time, cost, and customer satisfaction. According to FAA, it has followed this system for acquiring the individual free flight technologies. FAA also indicated that it plans to use both Free Flight Phase 1 and Flight 2000 (now the Free Flight Operational Enhancement Program) to gather the data needed to conduct investment analyses before deploying free flight technologies on a larger scale.

Detailed Plans Are Needed for Implementing Free Flight

Stakeholders believe that more detailed plans are needed to provide the aviation community with assurances that moving forward with free flight is warranted. They believe that these plans should include the results of cost/benefit analyses, new procedures, and schedules for equipment installation.

Users Seek Assurance That Technology Investments Will Provide Benefits

Because they expect that equipping with free flight technologies will be expensive, many users believe that FAA needs to demonstrate the near-term benefits of the new equipment—especially given FAA's poor record of delivering promised benefits. As part of its efforts to develop plans for implementing free flight, FAA has conducted cost/benefit analyses to provide justification for free flight investments. However, stakeholders have raised concerns that these analyses have focused almost exclusively on the benefits to FAA. As a result, they believe that these analyses are of

[22]P.L. 104-50 directed FAA to develop a new acquisition management system, which the agency implemented in Apr. 1996.

little value to users that must make business decisions about investing in new technologies. As one airframe manufacturer noted, FAA should develop a convincing case for changing the functions of the present system before selecting new technologies.

While users expressed a desire for studies that consider their business needs, one airline official told us that meaningful cost/benefit analyses are very difficult to establish for the airline industry because the costs and benefits of equipping will vary considerably both among and within airlines. For example, the cost of investments and associated benefits will vary with factors such as (1) the cost of installing new avionics—including the cost of retrofitting older aircraft, (2) the timing of requirements for completing the installation of equipment, and (3) the routes flown. Even though these factors vary from one airline to another, some airlines expect FAA to conduct analyses that demonstrate that technology investments will be cost-effective for them.

Similarly, DOD and general aviation users are concerned about potential penalties for not equipping their aircraft with technologies that will be needed to conduct operations under free flight. For example, DOD officials told us that they need more detailed information about whether—or under what circumstances—they may be excluded from certain airspace if they fail to equip with free flight technologies. DOD is also concerned that the lack of specificity in FAA's plans may negatively affect its ability to meet its mission readiness requirements—including the ability to fly cost-efficient and effective routes. Some stakeholders have expressed concern that the cost of equipping with avionics for participation in the free flight environment may be prohibitive for the recreational end of the general aviation community. FAA is aware of this concern and plans to use the Flight 2000 demonstration (now the Free Flight Operational Enhancement Program) as a means for streamlining its process for ensuring the safety of new equipment for flight operations and developing affordable avionics for general aviation.

New Procedures for Free Flight Need to Be Developed

A number of stakeholders told us that in order for FAA and users to fully exploit new capabilities to maximize the air traffic control system's safety, capacity, and efficiency, the agency will need to develop procedures that will be used in the free flight environment. Such procedures will affect a wide range of operations. For example, new procedures will be required to approve, integrate, and deploy new technologies. New procedures will also be needed to enable pilots and controllers to use the new technologies. Hence, some stakeholders noted that it will be important for

FAA to make explicit any changes in pilots' and controllers' roles and responsibilities. For example, if pilots and controllers are to share responsibility for making decisions about altitudes, speeds, and routes, the procedures need to be well defined. Under Free Flight Phase 1, the agency plans to implement new procedures as needed to demonstrate the use of new air traffic management tools that controllers will use to improve conflict detection and air traffic sequencing, among other things. Similarly, under Flight 2000 (now the Free Flight Operational Enhancement Program), FAA plans to develop new procedures for the new communication, navigation, and surveillance technologies that will be used by pilots and controllers.

FAA is aware of the need to develop procedural changes for operations under free flight and is currently working with the aviation community to develop these new procedures. However, some stakeholders are concerned that the development and implementation of new procedures will not occur in a timely fashion. One of these stakeholders further stressed that having new equipment and technology working together is not enough, without new procedures, to deliver the benefits promised under free flight.

Equipment Installation Will Require Adequate Lead Time

Commercial airlines and DOD require adequate lead time to plan for the cost-effective installation of new equipment. To facilitate an efficient equipment installation process, FAA will need to work with users to consider their unique needs as they develop plans for moving to free flight operations. For example, to minimize costs, airlines would prefer to install new avionics within an aircraft's regularly scheduled maintenance cycle. In addition, airlines do not want to install new equipment too early because they want to be able to take advantage of opportunities to purchase the best technologies at the lowest cost; however, they do not want to equip too late and miss out on the benefits. Similarly, because DOD must request funding well before installing new equipment, it needs ample lead time to develop budget requests and installation schedules for many of its aircraft, which number more than 16,000. Therefore, it is important for FAA to make timely decisions about future technology requirements and stick with those decisions to give all aviation user groups the lead time needed to ensure that their purchases are cost-effective and their installation schedules are efficient.

To provide for a smooth transition, FAA has been working with DOD and other users to move forward with the selection of new technologies for operations under free flight. FAA's most recent draft NAS architecture (blueprint) represents the agency's attempt to provide the level of detail requested by the aviation community. However, some stakeholders have expressed concern that the draft architecture is too general to use in planning for future technology upgrades. For example, an airline representative noted that when airlines place orders for new aircraft, they request systems that provide maximum flexibility for later modifications or upgrades. However, future free flight equipment upgrades will still be costly, and the sooner FAA decides which technologies will be required for operations under free flight, the more effectively airlines can plan for those upgrades.

Effective Collaboration With Stakeholders Is Key to Developing Implementation Plans

Collaboration between FAA and stakeholders is critical to developing plans that will have the level of buy-in needed to start implementing free flight. FAA's recent experiences in developing modernization plans have pointed to the need to work collaboratively with the aviation community from the onset of a given program to help ensure the effective resolution of issues as plans are developed. In March 1998, FAA and the aviation community reached consensus to begin implementing Free Flight Phase 1—including consensus on which technologies will be deployed and where. In addition, under this first phase, steps will be taken to identify and mitigate the risks associated with inserting new technologies and procedures into an operating air traffic control system.

In contrast, until recently FAA and stakeholders have been sharply divided over the agency's plans for conducting Flight 2000—a limited demonstration of free-flight-related communication, navigation, and surveillance technologies—primarily in Alaska and Hawaii. Problems began when the proposal was announced without consulting users and have persisted, despite FAA's efforts to work collaboratively with stakeholders to resolve them. While many stakeholders we interviewed agreed with the need for FAA to conduct an operational demonstration of free flight technologies and related procedures, they had strong reservations about the utility of conducting such a demonstration in Alaska and Hawaii. In their view, few of the lessons learned would be transferable to operations in the continental United States, where free flight implementation will ultimately focus. In addition, stakeholders expressed concern that FAA has not focused enough attention on developing the detailed plans that it needs for conducting the demonstration, as required by the agency's acquisition management system. In fact, the Department of Transportation's fiscal year 1998 appropriation act prohibited FAA from spending any fiscal year 1998 funds on the Flight 2000 program. In the accompanying Conference Report for the act, the conferees noted that additional financial and technical planning was needed before the Flight 2000 demonstration program could be implemented. The Congress has not yet decided whether to fund this demonstration program in fiscal year 1999.

To address these concerns, FAA has been working collaboratively with stakeholders—through RTCA—to develop a roadmap (general plans) for restructuring Flight 2000. These efforts have resulted in the (1) development of selection criteria for the operational capabilities to be used, (2) selection of demonstration sites in Alaska and the Ohio Valley, (3) selection of nine operational capabilities (see app. III), (4) proposed change of the program's name from Flight 2000 to the "Free Flight Operational Enhancement Program," and (5) revision of the time frame (1999-2004) for conducting the demonstration program. FAA is currently considering this RTCA proposal. FAA and stakeholders realize that they will need to continue to work collaboratively to refine these plans. The latest collaborative efforts appear to be a positive step toward developing the type of detailed plans FAA needs to carry out the demonstration and secure the necessary funding.

FAA Needs to Address Outstanding Issues Related to Technology Development and Deployment

Stakeholders and FAA officials identified several concerns about technology development and deployment that need to be resolved. Key among these were (1) the pace and cost of the agency's process for ensuring that new equipment is safe for its intended use, (2) issues related to human factors, (3) uncertainties surrounding the use of GPS as a sole means of navigation, and (4) issues associated with the use of digital communication technologies.

Efforts Are Under Way to Address Shortcomings of FAA's Certification Process

Many stakeholders and FAA officials stated that FAA's certification process—methods for ensuring that new equipment is safe for its intended use—is a key challenge to the implementation of free flight because it takes too long and costs too much; they urged that the process be streamlined. The certification process could be problematic for free flight because many new types of equipment, such as those that are required for the use of new digital communication technology, will need to be certified before they can be implemented. As one aviation community stakeholder noted, "If something is going to change the aviation system, it has to go through the certification knot hole."

Recognizing that the certification process poses a barrier to implementing free flight, FAA has taken a number of steps to address this problem. For example, FAA asked, and RTCA agreed, to convene a task force to examine ways to improve the agency's existing certification practices. The first meeting took place in June 1998, and the task force expects to report to FAA within 6 months. Among other things, this task force will (1) develop baseline information on the current system—including a review of avionics, infrastructure, and satellite needs; (2) consider human factors in the certification process—including how best to integrate human factors into the system's design and operations; (3) identify ways to improve the current certification process—including an attempt to determine an acceptable range of failure for technologies and metrics for technology design and performance; and (4) review FAA's certification services—including what customers should expect from the agency and alternative methods of satisfying certification requirements, such as granting approval authority for specific types of technologies to Centers of Excellence or individuals. In addition, RTCA has a special committee that is reviewing the use of digital communication technologies for free flight, including the development of standards that FAA could use to develop certification requirements. Furthermore, the agency plans to use the Flight 2000 (now the Free Flight Operational Enhancement Program) demonstration of free flight communication, navigation, and surveillance technologies as an opportunity for streamlining the agency's equipment certification process.

Several stakeholders told us that while the certification process could be streamlined, both FAA and stakeholders need to take a careful approach. They noted that the present system may be cumbersome, but it is providing the desired level of safety. If standards are going to be relaxed, then redundancies need to be built into the system to ensure that modifications to the certification process either maintain or improve upon existing levels of safety.

Implementation of Free Flight Hinges on the Satisfactory Resolution of Human Factors Issues

Many stakeholders told us they believe that the successful implementation of free flight hinges on issues related to human factors, such as the ability and willingness of pilots, controllers, and maintenance staff to shift to a new system of air traffic management. Among the concerns raised are the need to (1) define the type of training that will best prepare human operators for the transition; (2) provide a reasonably paced training schedule to help ensure that pilots, controllers, and maintenance staff, in particular, are not overburdened with too many changes at one time; and

(3) identify the risks associated with changes in technologies and procedures and the potential effects of these changes on human operations in a free flight environment. For example, a recent report by the National Research Council on human factors and automation raised concerns that, among other things, the increased use of automation may lead to confusion among pilots, controllers, and airline operations personnel over where control lies, especially in a free flight environment.[23] As a result, the report recommended that until these and other human factors issues are better understood, the introduction of automated tools should proceed gradually and decision-making authority should continue to reside on the ground with controllers.

A related issue is the need to incorporate the consideration of human factors into the product development cycle to avoid costly and cumbersome changes at the end of the development process. An FAA human factors official told us that FAA has learned a lot from its experience with the Standard Terminal Automation Replacement System (STARS) about the need to involve users in considering human factors throughout the product development cycle—from the mission needs statement, forward.[24] This official stressed that the agency can pay to consider human factors throughout the acquisition cycle or pay more later, as it is doing with STARS, to fix the problems that arise when these factors are not considered. Furthermore, when human factors are not considered along the way, problems cannot always be fixed. Fewer options are available at the end of a development cycle for modifying a given technology. Stakeholders agreed with this assessment.

While FAA has developed guidelines for considering human factors during the technology development process, it has not established a formal requirement for using these guidelines. In June 1996, we reported that FAA's work on human factors was not centralized, and we recommended that the Secretary of Transportation direct FAA to ensure that all units coordinate their research through the agency's Human Factors Division.[25] According to some FAA officials and one stakeholder, such coordination is

[23]The Future of Air Traffic Control: Human Operators and Automation, National Research Council (Feb. 1998).

[24]Both controller and maintenance worker unions identified numerous human factors problems with STARS that need to be resolved before the system is deployed. According to union representatives, many of these problems resulted because users were not adequately involved in the development of this system. While progress has been made in addressing concerns identified by both unions, outstanding issues remain, including the source of funds for implementing all solutions.

[25]Human Factors: Status of Efforts to Integrate Research on Human Factors Into FAA's Activities (GAO/RCED-96-151, June 27, 1996).

still lacking and the agency's programs would benefit from assigning responsibility for human factors to a higher level within FAA so that these issues can receive sufficient attention from the agency's senior management. In addition, several stakeholders stressed the importance of retaining the same members on teams that address concerns about human factors through the entire development process. One of these stakeholders believes that such continuity will help ensure that the team's efforts are not derailed late in the process by the inclusion of new members and the introduction of a range of new issues and methods of resolving them.

Human factors must also be considered in the operating environments where technologies will be deployed. According to one stakeholder involved in human factors work, because the air traffic control system has evolved—rather than being designed—it does not operate in a homogeneous fashion, and when the system is changed, the effects on humans can vary widely. For example, both en route and terminal facilities tailor their operations in many ways to factor in local conditions. As a result, this stakeholder stressed that as many as 1,000 letters of agreement between various components of FAA and users making adjustments to operating rules and procedures may exist—making it difficult for the agency to generalize across the system when considering the introduction of changes or improvements. In addition, under free flight, users and controllers (as well as maintenance staff) will rely more heavily on automated technologies to carry out their responsibilities—making the integrity of the system even more critical than it is now and increasing the need for more redundant systems and training to ensure that controllers can successfully switch, if necessary, to manual control techniques.

FAA Needs to Determine if GPS Augmentations Will Provide the Primary or Sole Means of Navigation

Satellite navigation provides precise information on the position of aircraft and offers the potential for the required distances between aircraft to be safely reduced and, in turn, for the air traffic control system's capacity to be increased. FAA initially planned its augmented satellite navigation system to be a sole means of navigation under free flight.[26] However, FAA and stakeholders have expressed concerns about the vulnerability of an augmented satellite system to both intentional and unintentional (e.g., radio frequency interference) jamming, and about problems associated with the system's weak signal. In view of these concerns, the Air Transport Association and the Aircraft Owners and Pilots Association have, in

[26]If GPS were used as a sole means of navigation, aircraft would not be required to carry additional types of equipment for navigation. However, if it were used as a primary means of navigation, aircraft operators would be required to carry additional navigation equipment or to have additional restrictions placed on when and where they can fly.

coordination with FAA, developed plans for a risk assessment of augmentations to satellite navigation. A research organization was selected in July 1998 to conduct the assessment, and a final report is expected in January 1999.

An Air Transport Association official told us that this risk assessment will address concerns about the vulnerability of satellite navigation and stressed that such a study is critical because the use of satellite navigation as a sole means of navigation is the centerpiece of FAA's architecture (blueprint) and is the basis for the agency's cost/benefit analyses. According to this official, a risk assessment is needed to identify the risks and develop mitigation plans and cost estimates for mitigating each risk. The results of this study could affect both the costs and benefits for FAA and users because if FAA does not use the augmented system as a sole means of navigation, it could incur additional costs to retain some portion of its ground-based navigational aids. Similarly, users may find it necessary to maintain existing equipment and to purchase new equipment under free flight.

Users Await FAA's Decisions About Data Link

FAA and stakeholders consider digital communication technologies—commonly referred to as data link—as critical to implementing free flight. FAA expects that the use of data link—in combination with other free flight technologies—will improve safety, increase capacity, reduce costs, and enhance the productivity of humans and equipment. Data link will replace or supplement many of the routine voice interactions between pilots and controllers with nonvocal digital data messages. For example, during peak periods, one controller often may be required to communicate on a single radio channel with 25 or more aircraft—leading to possible operational errors and system delays. FAA believes that using data link will (1) reduce nearly one-quarter of all domestic operational errors—caused directly or indirectly by miscommunication between pilots and controllers, (2) relieve highly congested voice communication channels, and (3) save the airlines millions of dollars annually on communication-related delays that occur during both taxi and in-flight operations.

Data link comprises three components: (1) software applications—including Controller Pilot Data Link Communications (CPDLC), weather information, and Automatic Dependent Surveillance (ADS); (2) hardware systems installed on the ground and avionics in the cockpit; and (3) the communication medium that allows for the transfer of data between the ground and airborne equipment. FAA is responsible for implementing ground systems, and the aviation community is responsible for implementing airborne systems. As partners, both FAA and the aviation community are responsible for ensuring the interoperability of these systems.

Stakeholders told us that despite the importance of data link, many issues remain unresolved. Chief among these issues is the lack of agreement within FAA on how, when, and at what pace to proceed with the use of data link. This lack of agreement may be attributed, at least in part, to the fact that data link efforts are being managed and implemented by different organizational elements of FAA and by the aviation community. Recognizing this, FAA has been working with stakeholders to reach agreement on data link issues. In May 1998, a group of FAA officials and stakeholders under the Administrator's NAS Modernization Task Force began developing a consensus plan for implementing controller pilot data link in the en route environment. In July 1998, this group presented its plan to RTCA for consideration. In August 1998, RTCA modified the plan and endorsed the implementation of CPDLC Build 1 as part of Free Flight Phase 1—recommending that the location and communication medium for CPDLC Build 1 be changed. FAA—in consultation with stakeholders—intends to further develop the plans for deploying CPDLC Build 1 by the end of 1998. FAA's approval is expected by early 1999.

Other Outstanding Issues May Limit Effectiveness of Free Flight's Implementation

A number of other issues were identified by FAA officials and stakeholders as needing resolution for free flight to be implemented successfully. Among these issues were the need to (1) coordinate modernization activities with the international aviation community, (2) integrate free flight technologies, and (3) address airport capacity issues.

FAA Needs to Ensure Global Coordination of Its Modernization Efforts

Airlines that operate internationally and DOD believe that FAA needs to work diligently to ensure that, to the extent possible, carriers do not have to purchase multiple types of avionics to operate in different parts of the world. Currently, both FAA and various elements of the aviation community are working collaboratively with their international counterparts on a number of modernization issues. For example, FAA is a member of an airline-led group with international participation—including Eurocontrol[27]

[27]Eurocontrol is the organizational entity that addresses air traffic management issues for the European member states.

and several foreign airlines—known as the Communication, Navigation, and Surveillance/Air Traffic Management Focused Team. The purpose of this team is to facilitate the implementation of new communication, navigation, and surveillance and air traffic management technologies by developing consensus among global airlines on economic issues. In addition, the agency is working with the European community on human factors issues and data link applications. However, some stakeholders question the sufficiency of the agency's efforts to coordinate technology selection decisions that will allow users to operate worldwide. Because the airline industry is becoming increasingly global, it requires the development of compatible operational concepts, technologies, and systems architectures throughout the world. One airframe manufacturer noted that the airlines are increasingly demanding global solutions to minimize the cost of changes to avionics and flight systems. The costs of purchasing new avionics, retrofitting them into the aircraft (and the down time required), and training pilots in their use for a large fleet of airplanes will quickly exceed any benefits if these benefits are not realized as soon as additional or improved capabilities are introduced.

According to some stakeholders, FAA has historically been the international leader in air traffic control modernization efforts—a position that has given the agency the flexibility to develop and deploy technologies that best serve the needs of users in the United States. However, many stakeholders expressed concern that FAA's position as the international leader in this arena has eroded in recent years. According to some of these stakeholders, the United States may have to follow the lead of the European community in selecting the types of new technologies that will be used under free flight. For example, some stakeholders noted that Europe is at least 3 years ahead of the United States in developing and deploying the data link technology that will serve as a centerpiece for implementing free flight. While several stakeholders noted that valuable lessons may be learned from the Europeans' work on data link, one stakeholder stressed that it is important for the United States to position itself so that it can make decisions about technology requirements that best reflect the needs of U.S. operations.

FAA Needs to Integrate Free Flight Technologies

Some FAA officials and stakeholders told us that the agency needs to integrate free flight technologies with one another and into the operating air traffic control system. This integration is expected to allow FAA and users to fully exploit the capabilities of these technologies to help ensure that promised improvements in safety, capacity, and efficiency are realized. For example, as noted in chapter 2, FAA has new technologies that are expected to improve the efficiency of operations at high altitudes, close to the terminal, and on the ground. Because some of these technologies have not been designed to work together, some stakeholders and FAA officials contend that their potential benefits—e.g., allowing the distance between aircraft to be safely reduced, when practical, throughout a flight's operation—will not be maximized unless they are integrated.

One airframe manufacturer noted that the key impediment to changing the NAS is not new technology, but how to integrate that technology into an operating NAS. As a result, care must be taken to help ensure that planned changes in operations, procedures, and airspace usage will not adversely affect safety and will meet users' future needs. Another stakeholder noted that integrating new technologies (and associated procedures) into the present operating system is difficult because there are complex interdependencies between the technologies currently being used—making incremental changes to the system complex and the consequences of introducing abrupt changes unpredictable. Stakeholders have raised concerns that FAA does not have sufficient internal expertise to complete integration tasks. FAA officials acknowledge that they do not have the internal expertise or experience to do the avionics systems integration work for Flight 2000 (now the Free Flight Operational Enhancement Program); the agency plans to hire an integration contractor to do this work. FAA believes that it has sufficient expertise to do the remainder of the integration work required for free flight. However, to enhance expertise within the agency, FAA has identified competencies essential to efficiently manage complex acquisition programs and is providing a variety of opportunities for staff to further develop their expertise.

Airport Capacity Issues Need Attention

Stakeholders questioned whether FAA is paying enough attention to increasing airport capacity. Many stakeholders stressed that using free flight in the en route environment may get aircraft to their destinations sooner, but the planes may then be delayed by limits on airport surface capacity, such as too few runways and gates. Several stakeholders also stressed that poor weather conditions limit airports' capacity and said that more sophisticated technology is needed to predict hazardous weather conditions so that airports' capacity can be optimized. In June 1998, we reported that FAA has not assigned weather information a high priority in its plans for the NAS architecture.[28] Because weather information is not considered critical, research on weather systems is often among the first to be cut—potentially jeopardizing mulityear studies of weather problems affecting aviation. Given the significant impact of hazardous weather on aviation safety and efficiency, improving the weather information available to all users should be one of FAA's top priorities. The agency is taking steps to address its shortcomings in this area, and in fiscal year 1999, FAA is elevating weather research as a funding priority.

[28] Aviation Safety: FAA Has Not Fully Implemented Weather-Related Recommendations, (GAO/RCED-98-130, June 2, 1998).

RTCA's Free Flight Recommendations

On October 26, 1995, RTCA Task Force 3 issued a report[29] detailing the recommended actions and time frames for gradually implementing free flight. These recommendations were divided into three categories—(1) near term (1995 through 1997),[30] (2) midterm (1998 through 2000),[31] and (3) far term (2001 and beyond).[32] The following are the recommendations from this RTCA report. FAA identified 11 recommendations related to Free Flight Phase 1—these are shown in bold.

Near-Term Recommendations, 1995-97

1. The Federal Aviation Administration (FAA), in cooperation with users, must develop new procedures which use airplane Random Navigation/Area Navigation (RNAV) capabilities to reduce congestion over waypoints. Such procedures should be expedited for the top 50 airports.

2. Institute a process to quickly develop the standards, criteria, procedures, and training programs necessary to expand implementation procedures for use of area navigation equipment capabilities, including vertical guidance, to increase capacity and operating efficiency in terminal areas.

3. Review existing air traffic control (ATC) procedures to identify changes for increased use of RNAV routes below Flight Level 180.

4. The planned expansion of the National Route Program (NRP) should be continued.

5. Where appropriate, decrease 200 nautical mile radius restriction for NRP filing.

6. Develop mechanisms to provide predeparture feedback to the flight planners on potential impacts of requested flight plans, changes to requested flight plans, and systems constraints causing those changes.

[29]Final Report of RTCA Task Force 3: Free Flight Implementation, RTCA (Oct. 26, 1995). In Aug. 1996, RTCA published a follow-on action plan that describes the initiatives needed to implement each of the recommendations. See RTCA Action Plan (Aug. 15, 1996).

[30]With one exception, near-term action items are designated by number. The following recommendation—listed as B—while not designated with a number, falls after recommendation 23. Recommendation B states, *Work with the user community to achieve consensus on the role and timing of Automatic Dependent Surveillance-Broadcast [ADS-B] technology in delivering specific near- and long-term benefits.*

[31]Midterm action items are prefaced with MT.

[32]Far-term action items are prefaced with FT.

7. Implement rationing-by-schedule during ground delay programs.

8. Establish more flexible ground delay program procedures and supporting decision support systems (DSS).

9. Establish a coordinated effort among military, FAA, and National Airspace System (NAS) users to define the information and capabilities necessary to improve civil use of Special Use Airspaces (SUA) when not being utilized by DOD.

10. An operational trial in one or more SUA should be conducted to demonstrate how improved information exchange on the status of SUA can improve civil use of SUAs when not being utilized by DOD.

11. Develop and implement real-time SUA notification between DOD and FAA, and between FAA and flight planners. A program plan is needed in the near term.

12. Streamline the FAA certification process to reduce time and costs for approval and fielding of new and emerging technologies.

13a. In collaboration with NAS users, the FAA should make a decision on the initial air/ground data link to be implemented for domestic ATC communications, navigation, and surveillance.

13b. The FAA should collaborate with the airspace users in the continued development of oceanic data link (i.e., Satellite Voice and Data Communications [SATCOM], High Frequency [HF] data link).

14. Improve telecommunication mechanisms to enhance the free flow of information between users and the Traffic Flow Management (TFM) system on a machine to machine basis.

15. Incorporate airline schedule updates (e.g., company delays and cancellations) in FAA decision support systems and decision processes.

16. Enhance, if possible, or replace the current Air Traffic Management (ATM) monitor/alert function, including, but not limited to, a means of measuring controller workload and complexity.

17. Expedite the deployment of digital Automatic Terminal Information Service (ATIS), automated taxi clearance and

expanded use of a standard taxi clearance as appended to the Pre-Departure Clearance (PDC). Expedite expansion of PDC to additional 27 sites. Evaluate expansion beyond the planned 57.

18. FAA should initiate the development of the standards for a cockpit situational awareness display of traffic information.

19. Deploy a ground-based conflict probe in the near term to accelerate the selection and development of a conflict probe with automated planning aids to assist controllers in the identification and resolution of conflicts.

20a. Expedite the implementation of the technologies and capabilities (e.g., Center TRACON Automation System [CTAS]) necessary for improved transition to, from, and operations in the terminal airspace, including the ability to sequence and schedule aircraft arriving on unstructured routes.

20b. Move mature elements of CTAS forward out of research and development (R&D) into implementation ensuring adherence to free flight principles.

21. In cooperation with airspace users, investigate the technical feasibility, safety, cost, and benefits of using Global Positioning System (GPS) Wide Area Augmentation System (WAAS) as an en route vertical reference, e.g., for Reduced Vertical Separation Minima (RVSM).

22. The FAA should support the Meteorological Data Collection and Reporting System (MDCRS) to enhance the quality and quantity of real-time aircraft-reported weather information.

23. Develop the capability—starting with existing capabilities—to generate more accurate forecasts on convective weather for use in flight and operational planning.

24. Develop methodology and tools to measure and predict dynamic density.

25. Develop, evaluate, and implement TFM capability for a cooperative exchange of information amongst the users and the FAA that will enable user involvement in the FAA's TFM decision making process.

25a. Building on existing activities, such as Traffic Flow Management-Architecture and Requirements Team (TFM-ART) and FAA-Airline Data Exchange (FADE), and related programs, the FAA and users must determine the details of an improved user-TFM interaction.

25b. In concert with the users, FAA must aggressively pursue the testing and implementation of development programs, and/or more flexible procedures, aimed at supporting the cooperative exchange of real-time data and information between the users and TFM system. Start now by developing TFM scenarios with the users that substitute controlled time of arrival (CTA) instead of the currently employed departure clearance time. Evaluate this soon at one airport.

26. FAA and users should establish procedures for aircraft to aircraft separation when separation responsibility may be transferred to the aircraft by the air traffic service provider on a case by case basis.

27. Implement precision missed approaches and precision simultaneous approaches and departures.

28. Investigate the possibility of increasing runway acceptance by permitting two aircraft to occupy the runway at the same time.

29. Additional expansion of the NRP below Flight Level 290 should be explored. Accelerate modeling and analysis efforts needed to facilitate the continued expansion of the NRP.

30. Issue an Advance Notice of Proposed Rulemaking regarding implementation of domestic reduced vertical separation minima (RVSM) above Flight Level 290.

31. The FAA should determine the requirements for reduced en route horizontal separation standards, including surveillance performance.

32. Begin rulemaking to remove the 250 knots below 10,000 feet restriction in Class B airspace.

33. The FAA should study human perceptions and responses associated with the time and distance buffers that separate aircraft (protected and alert zones). FAA must determine that proposed changes in separation rules and maneuver limits do not increase perceived hazards, statistical risks, and experienced discomfort. FAA must show that the proposed changes

will make the present system more efficient, safe, or economical before implementation.

34. Real-time human-in-the-loop simulations should be conducted to systematically study controller and pilot behaviors, interactions, and effects within NAS environments that represent dynamic densities and sector configurations anticipated for free flight.

35. Reemphasize the role of the Airport Improvement Program in increasing airport capacity.

Midterm Recommendations, 1998-2000

MT1. Increase FAA Air-Route Traffic Control Center (ARTCC) decision support capabilities as soon as possible to include the total U.S. navigational database.

MT2. Accelerate and expand programs to support GPS/WAAS as a primary navigation system (e.g., airport surveys, update FAA orders, precision approaches at majority of airports in the contiguous United States, Hawaii, Southern Alaska, and the Caribbean).

MT3. Ensure that requirements for Standard Terminal Automation Replacement System (STARS) for Terminal Radar Approach Controls (TRACONS) and Display System Replacement (DSR) for ARTCCs be modified to include a provision, i.e., a "hook" for receiving, processing, and displaying Automatic Dependent Surveillance-Broadcast (ADS-B) signals and data link.

MT4. Develop and implement technology for the dissemination of weather products and flight information to the cockpit. Development of FIS application standards should be done in coordination with cockpit traffic display standards.

MT5. FAA must develop and deploy dynamic/adaptive sectors as a means to facilitate free flight operations.

MT6. Initiate the development of, and implement, ADS to support user preferred trajectories in non radar areas; includes ground infrastructure (communications and automation) and user equipage.

Far-Term Recommendations, 2001 and Beyond

FT1. Expand the number of airports to receive surface surveillance capability.

FT2. The FAA should define a surveillance architecture and infrastructure for en route and terminal airspace incorporating both dependent and independent surveillance elements. The architecture must meet the requirements for reduced separation standards, improved coverage, and lower-cost maintenance determined by other related studies and investigations, and should facilitate enhancing both near-term surveillance capabilities and those required for mature free flight.

FT3. Determine Local Area Augmentation System (LAAS) capability to enable increased availability of Category I, II, III approaches and implement LAAS, as appropriate.

Status of Selected RTCA Recommendations Related to Free Flight Phase 1, as of July 1998

RECOMMENDATION	INITIATIVE	STATUS[a]
4. The planned expansion of the National Route Program (NRP) should be continued.	a. FAA Notice 7110.147, National Route Program, dated 12/20/95, has been revised to create a more aggressive expansion form.	Completed. Effective 2/26/97 Notice will be incorporated into FAA Order 7210.3 chapter 18.
	b. Conduct ATC system impact analysis and modeling.	Completed by MITRE-CAASD.
	c. NRP expansion to FL 290.	Completed 10/96.
	d. Conduct postexpansion workload analysis to identify issues and lessons learned from planned expansion to FL 290.	Database for tracking issues concerning NRP developed. Ongoing historical data collection.

RECOMMENDATION	INITIATIVE	STATUS[a]
5. Where appropriate, decrease 200-nautical-mile- radius restriction for NRP filing.	a. Examine feasibility of reducing the 200-nautical-mile radius using existing modeling and analysis capabilities. Analysis should address issues such as workload and redesign of national airspace. Initial simulation analysis completed. Additional simulation and Human in the Loop (HITL) analyses are planned.	MITRE Corporation did some initial analysis on reduction of 200-nautical-mile restriction in increments of 50 nautical miles. The results were not especially useful because the modeling was designed to set a baseline and did not reflect realistic expectations of increased airline participation. Further consideration indicated this was not a realistic approach because (1) the ingress/egress mileage would vary greatly from airport to airport and (2) programming of airline databases to account for airport variations would be cumbersome and time consuming.
	b. Develop procedures for use of Instrument Departure Procedures (DP) and Standard Terminal Arrival Routes (STAR) for filing a Standard Instrument Departure (SID) to the NRP to a STAR at destination.	Development of the DP/STAR goal to allow users to file Instrument Departure Procedures transitions to join an NRP route, and exit an NRP route via the transition of a Standard Terminal Arrival Route.
	c. Begin testing and evaluation of DP/STAR egress/ingress program at airport city pairs as agreed upon by FAA and industry working groups.	A notification under the provisions of the collective bargaining agreement was issued to NATCA on 2/10/97.
	d.Implement DP/STAR egress/ingress program nationally. Identify and disseminate ingress/egress points inside or outside 200-nautical-mile radius (those that do not have DPs/STARs).	•On 4/1/98, a committee consisting of National Air Traffic Controllers Association (NATCA), ATO-100/200, and the Airline Transport Association convened to outline the DP/STAR project and to provide national oversight. The National Business Aircraft Association and Regional Aircraft Association were invited to attend and will continue to be invited to participate on the committee.

(continued)

RECOMMENDATION	INITIATIVE	STATUS[a]
		•Regions and facilities will be tasked to review DP/STAR transitions to area airports to evaluate applicability to the DP/STAR goal.
		•Procedures for implementing the DP/STAR program have been developed and agreed upon by FAA and industry work group members.
		•Initial list of select cities has been developed consisting of 24 DPs and 11 STARs.
		•Coordination with NATCA on implementation of initial cities list completed 3/25/98.
		•Initial list of DPs/STARs changed. New list includes Denver, Albuquerque, Minneapolis/St. Paul, and Salt Lake City. A total of 14 DPs with 73 transitions, and 19 STARS with 40 transitions approved for implementation.
		•All transitions of each DP/STAR may not be available/published because of facility procedural constraints.
		•Advisory Circular 90-91B and FAA Notice 7210.468 defining program requirements published 4/15/98.
		•Workgroup met 7/8/98-7/9/98 to develop and agree upon next airports for implementation later in 1998.
		•Program name changed to “Departure Procedure/Standard Terminal Arrival Route Transition to the National Route Program.”
		Airports that do not have DP/STAR routes are not likely to be the primary departure/destination points of the users. After the DP/STAR program is implemented at most major sites, attention can be given to address those airports and determine a reasonable distance expectation for users to join a published route. (Published route indicating a jet or victor airway, as opposed to published preferred Instrument Flight Rules (IFR) route.) The latter are navigational aids.

RECOMMENDATION	INITIATIVE	STATUS[a]
6. Develop mechanisms to provide predeparture feedback to the flight planners on potential impact of requested flight plans, changes to requested flight plans, and system constraints causing those changes.	a. RTCA Special Committee (SC) 169 Working Group 5 to define detailed and prioritized near- and longer-term needs and benefits estimate, including requirements for a centralized database identifying NAS status for flight planning.	Data exchange mechanism in place. Traffic Flow Management (TFM) R&D activity with industry has indicated that this capability will evolve naturally at a later stage of data exchange development. Therefore, work on this recommendation is being deferred until the appropriate time.
	b. FAA will identify, with industry, near-term procedural changes to increase information available on system constraints for flight planning, including general aviation requirements.	
	c. Working Group 5 will develop operational concept automated predeparture feedback and flight plan amendments for operations via direct interface between the Airline Operations Centers (AOC) and traffic management.	
	d. Define interface requirements between AOAS/DOTS.	

RECOMMENDATION	INITIATIVE	STATUS[a]
9. Establish a coordinated effort among military, FAA, and NAS users to define the information and capabilities necessary to improve civil use of SUAs when not being utilized by DOD.	a. Establish working group of military, FAA, other government agencies, NATCA, and users to determine specific information requirements concerning SUA availability and time frames for notification of availability.	Additional activities/site visits the SUA work group has been involved with: Delta Airlines Operations Center (AOC), American Airlines AOC, Jacksonville Air Route Traffic Control Center (ARTCC), Fort Worth ARTCC, Jacksonville Fleet Area Control and Surveillance Facility, Fort Worth Joint Reserve Base, White Sands Missile Range, USS John C. Stennis aircraft carrier, Gainesville Automated Flight Service Station (AFSS), Fort Worth AFSS, Gulf of Mexico Users Meeting, and the Government/Industry Aeronautical Charting Forum.
	b. Implement FAA system of tracking SUA availability (SAMS).	SAMS has been installed at all ARTCCs, Honolulu and San Juan Combined Center-Military Radar Approach Control (RAPCON), Fayetteville, High Desert, and Pensacola TRACONs, and Fort Worth AFSS.

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RECOMMENDATION	INITIATIVE	STATUS[a]
	c. FAA will develop rules and procedures to support identified requirements for supporting improved civil access to SUA.	The procedures to disseminate SUA schedules developed in Action Item 10a have been replicated at Jacksonville ARTCC and New York ARTCC for warning area information, and Albuquerque ARTCC for White Sands Missile Range information. The Industry/Government Aeronautical Charting Forum is reviewing the work group's request to chart frequencies for SUA information on aeronautical charts used by general aviation pilots, and to display Air Traffic Control Assigned Airspace on pertinent aeronautical charts.
	d. DOD SUA scheduling system to provide electronic schedules to FAA systems by 1998.	Negotiations are ongoing between FAA and DOD; tentative initial operating capability is 8/98.
	e. Define and implement interface between SAMS and Enhanced Traffic Management System (ETMS)/Notices to Airman (NOTAM)/other systems to allow for transfer of SUA information to users.	Remaining software development requirements include, but are not limited to, analysis reports and interfaces with Enhanced Traffic Management System, Military Airspace Management System, and distribution of the data to Flight Service Stations. ADTN2000 was selected as the telecommunications network for the SAMS v3.0 system. Installation of the network began in 9/96. Currently there are six sites remaining that are awaiting connectivity or line installation. In addition, Internet Protocol (IP) addresses have not been tested which provide connectivity to the main server site at the Air Traffic Control System Command Center (ATCSCC) and the other sites.

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RECOMMENDATION	INITIATIVE	STATUS[a]
	f. FAA will compare available capabilities with identified requirements to determine if additional infrastructure development (e.g., air/ground communication) is required. Cost/benefit of additional development will be assessed.	Free Flight working group was formed to address real-time SUA management as it applies to free flight. The group consists of representatives from FAA, commercial aviation, general aviation, DOD, Department of the Interior, (DOI), and NATCA. The group met and teleconferenced several times since their initial meeting 8/8/96, to address items 9, 10, and 11, including an on-site visit to Edwards AFB/R-2508 Complex. The following points have been made: (1) DOD policy of returning SUA back to the controlling agency (FAA) when not in use is considered fundamentally sound and supported by all concerned. The implementation of this policy was observed at Edwards AFB. (2) Non-DOD NAS users (commercial and general aviation) reiterated that they seek access to SUA when that airspace is not in use. (3) Non-DOD NAS users understand that their request to gain access to SUA, when that airspace is inactive, requires coordination and approval through FAA. (4) DOD requires flexible scheduling to accomplish its mission. Rigid scheduling requirements would not accommodate the many variables that could affect the mission, i.e., weather, telemetry/instrumentation, aircraft availability, etc.
		(5) Non-DOD NAS users indicated that they require SUA status information from FAA as soon as FAA knows it. This includes air traffic control assigned airspace (ATCAA) and its charting.
		(6) Information dissemination to non-DOD NAS users, by FAA, appears to be a major issue where most follow-on action must be focused. FAA acknowledges its responsibility for information sharing and those inefficiencies in information dissemination that need to be addressed, i.e., who gets the information, how do they get it, when do they get it, and where do they get it?

(continued)

RECOMMENDATION	INITIATIVE	STATUS[a]
	g. Establish a measurement capability to track SUA volume, utilization, and management.	Free Flight working group was formed to address real-time SUA management as it applies to free flight. The group consists of representatives from FAA, commercial aviation, general aviation, DOD, DOI, and NATCA. The group met and teleconferenced several times since their initial meeting 8/8/96, to address items 9, 10, and 11, including an on-site visit to Edwards AFB/R-2508 Complex. The following points have been made: (1) DOD's policy of returning SUA back to the controlling agency (FAA) when not in use is considered fundamentally sound and is supported by all concerned. The implementation of this policy was observed at Edwards AFB. (2) Non-DOD NAS users (commercial and general aviation) reiterated that they seek access to SUA when that airspace is not in use. (3) Non-DOD NAS users understand that their request to gain access to SUA, when that airspace is inactive, requires coordination and approval through FAA. (4) DOD requires flexible scheduling to accomplish its mission. Rigid scheduling requirements would not accommodate the many variables that could affect the mission, i.e., weather, telemetry/instrumentation, aircraft availability, etc. (5) Non-DOD NAS users indicated that they require SUA status information from FAA as soon as FAA knows it. (6) Information dissemination to non-DOD NAS users, by FAA, appears to be the major issue where most follow-on action must be focused. FAA acknowledges its responsibility for information sharing and those inefficiencies in information dissemination that need to be addressed, i.e., who gets the information, how do they get it, when do they get it, and where do they get it?

RECOMMENDATION	INITIATIVE	STATUS[a]
10. An operational trial in one or more SUA should be conducted to demonstrate how improved information exchange on the status of SUA can improve civil use of SUAs when not being utilized by DOD.	a. Technical working group (formed in Rec. 9a) identifies one or more SUAs for operational trials of data sharing with existing capabilities.	The working group recommended an operational trial at the R-2508 Complex (Edwards AFB). SUA information was disseminated by Oakland ARTCC via the ETMS mail system to air carriers with no disruption to DOD operations. The trial was conducted in 2/97 and 3/97 and required the cooperation and coordination of FAA's Western-Pacific Region Air Traffic Division, R-2508 Complex Control Board, Oakland ARTCC, High Desert TRACON, Los Angeles ARTCC, and the user community. A second trial commenced on 12/20/97 between New York metropolitan (JFK, LGA, EWR) airports and Orlando International Airport. Aircraft are being routed offshore and transitioned, if feasible, through the warning areas on a real-time basis.
	b. Identify FAA and DOD lead for this effort, and identify priority status of this effort.	Completed.
	c. FAA and DOD collect benefits and operational issues during trials.	FAA, DOD, and other users collected information during the operational trial at the R-2508 Complex. One airline stated it was saving $30,000 per month through fuel loading decisions for the trial, while there was no impact on DOD's operations. The procedure was implemented on a permanent basis at the R-2508 Complex. Data are still being collected for the Orlando International Airport trial.
	d. Results (costs and benefits) of operational trial will be fed into procedure and infrastructure development activities in Rec. 9.	The procedures for the R-2508 Complex were implemented at Jacksonville and New York ARTCCs for warning area information, and at Albuquerque ARTCC for the White Sands Complex of SUA. Data are still being collected for the Jacksonville trial.

(continued)

RECOMMENDATION	INITIATIVE	STATUS[a]
	e. FAA/DOD agreement on national procedures.	The following points were made: (1) The R-2508 Complex dynamically accommodates civil in-flight requests for flight within the R-2508 airspace. (2) Information sharing between DOD and FAA in the R-2508 Complex is accomplished very efficiently through a variety of electronic exchanges, as well as being physically collocated in the TRACON facility. (3) Information sharing between FAA and Non-DOD NAS users normally occurred on a tactical, real-time basis. (4) Filing and approval of more preferred routing through the R-2508 Complex in a southeast direction, i.e., J-110, with Oakland Center has been a problem for the airlines. Filing and approval of more preferred routing in the northwest direction through R-2508 via J-110 has not been a problem. (5) Participants are tasked to compile a list of SUAs that they believe would be candidates for another operational trial. Another on-site visit has been scheduled tentatively for the North Florida area. (6) The operational trial at the R-2508 Complex will be incorporated into standard operating procedures. (7) An attempt will be made to transfer this strategy to provide air carriers with information about the availability of certain airspace.

RECOMMENDATION	INITIATIVE	STATUS[a]
11. Develop and implement real-time SUA notification between DOD and FAA, and between FAA and flight planners. A program plan is needed in the near term.	a. The joint team (formed in Rec. 9a) will assess the need for real-time SUA notifications and will develop a program plan to reflect needed changes in systems, procedures, and training to implement real-time exchanges of schedule information.	The work group in Rec. 9 wanted FAA to provide the information to users as it is received.
	b. Examine needed internal and external FAA infrastructure changes to enable real-time SUA notification, such as an interface between SAMS and the Host.	The Host Replacement Mission Need Statement has been approved by FAA. The entry and display of SUA information will be available to the air traffic controller.

RECOMMENDATION	INITIATIVE	STATUS[a]
17. Expedite the deployment of Digital Automatic Terminal Information Service (D-ATIS), automated taxi clearance, and expanded use of a standard taxi clearance as appended to the Pre-Departure Clearance (PDC). Expedite expansion of PDC to additional 27 sites. Evaluate expansion beyond the planned 57.	a. Deliver all 57 tower data link sites for PDC and D-ATIS.	PDC is operational at all 57 sites. D-ATIS is operational at 49 sites, and the other 8 are awaiting completion of D-ATIS local refresher training. D-ATIS operation expected at remaining sites by 5/98.
	b. Complete Detroit demonstration of taxi route delivery.	Four-month demonstration under way, to be followed by a 1-month evaluation, expected to be completed by 6/98.
	c. Publish charted standard taxi routes for national implementation.	The activity is postponed until benefits have been assessed on the basis of the Detroit demonstrations' results.
	d. Free Flight Steering Committee identifies additional sites for tower data link services, conducts cost/benefit analyses, and makes recommendations to FAA.	No candidate sites for expansion have been identified.
	e. Notify Free Flight Steering Committee on decision for additional sites.	No candidate sites for expansion have been identified.

RECOMMENDATION	INITIATIVE	STATUS[a]
19. Deploy a ground-based conflict probe in the near term to accelerate the selection and development of a conflict probe with automated planning aids to assist controllers in the identification and resolution of conflicts.	a. Deploy mature components of present conflict probe and automated planning research at selected field facilities for concept development and evaluation. (Move from laboratory to field evaluation.) Efforts under way that may lead to operationally deployable capabilities include: User Request Evaluation Tool (URET) at Indianapolis and Memphis (ZID and ZME) Centers, Prediction Resolution Advisory Tool (PRAT) at Boston (ZBW) Center, User Preferred Routing Conflict Probe (UPR) at Denver (ZDV) Center, and Free Flight Evaluation Work Station at Kansas City (ZKC) Center.	The evaluation of the PRAT system at ZBW was completed in 9/96. PRAT is a source of potential requirements for the follow-on Initial Conflict Probe (ICP) capability. Full evaluation of PRAT was handicapped by issues associated with proprietary software. The field evaluation of the URET operational prototype system began in 2/96 at ZID and 6/97 at ZME and remains in progress. Daily use (8 hours per day, 5 days per week) of URET began at ZID in 9/97 and at ZME in 11/97 using the baseline software version D2.1. Evaluation of the Interfacility Automation (IFA) version D3.0 between ZID and ZME began in 10/97 and was completed in 2/98. D3.0 (without IFA) was implemented as the daily use software in 2/98. Daily use was expanded to 12 hours per day in 3/98.
		D3R3, a component of D3a1, to correct Red Route Processing and Airport Arrival Stream filtering, was delivered in 2/98 and evaluated in 3/98 and 4/98. D3R3 became the daily use software in 5/98. The remainder of the D3a1 (now D3a since the D3a2 delivery was eliminated) was to be delivered in 7/98.
		A preliminary Systems Specification and algorithmic definition documents for key algorithmic areas have been developed on the basis of URET evaluations done to date and evaluation reports.
		The initial technology transfer process from MITRE/CAASD to FAA and its development contractors for DSR ICP was completed in late 1997. Technology transfers continue on the additional functionality. A MITRE Technical Assessment Report positively assessed the URET operational concept and also identified the need for substantial re-architecture and re-coding of the software for full scale DSR ICP development. URET is presently regarded as a source of requirements and algorithms for both ICP and Future Conflict Probe (FCP).

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RECOMMENDATION	INITIATIVE	STATUS[a]
		An initial field trial of the UPR Transition Airspace Tool was conducted as a research activity at ZDV in 9/96. Simulations using the UPR Transition Airspace Tool with controllers were conducted in 11/96. A "shadow mode" (office area) version of the UPR Transition Airspace Tool was installed at ZDV in 12/96.
		A full field evaluation of the UPR Transition Airspace Tool was completed by NASA at Denver in 9/97. A process for technology transfer of the UPR Transition Airspace Tool additions to CTAS Build 2 was initiated in 5/97. The UPR Transition Airspace Tool is viewed as a source of requirements and reusable components for the FCP initiative.
		The Free Flight Evaluation System (FFES) is a MITRE/CAASD research activity at ZKC looking at long-term requirements for automation to support free flight. No detailed FAA explanation of FFES is planned. FFES is in the concept exploration stage. FFES is viewed as a source of requirements for the FCP capability and later enhancements.
	b. FAA, with users and NATCA, will develop an incremental plan and concept for deploying components of conflict probe prototypes to improve functionality. This plan will identify procedural and regulatory changes and agreements that will be needed to address issues of operational deployment.	FAA's development strategy for ICP has been focused on the URET operational prototype, user acceptance, and display refinement. A URET implementation viability assessment was completed in 12/96. MITRE/CAASD is continuing to refine detailed technical requirements for key areas; these areas include Interfacility Automation (IFA) and conflict probability prediction. Options being explored for the ICP implementation included re-architecting URET as an integral part of DSR to achieve the initial DSR ICP requirements and specifications.

(continued)

RECOMMENDATION	INITIATIVE	STATUS[a]
		A formal investment decision (JRC) on full-scale implementation of DSR ICP was scheduled for 3/98 but postponed because of the Core Capabilities Limited Development Free Flight Phase 1 (CCLD FFP1) initiative. Data collected for the JRC include cost, benefits, schedule, and technical requirements baseline data. This includes a benefits assessment conducted at the ZID DySim in 1/98.
		FAA has been analyzing a recommendation by RTCA/ATA for deploying URET to five additional sites. The proposed ARTCCs are Cleveland, Atlanta, Chicago, Memphis, Kansas City, Washington, and Indianapolis. The proposal includes options for URET as a stand-alone system similar to the ZID and ZME installations or integrated with DSR.
		Either would include functionality equivalent to URET D3.1. ATO and NATCA have indicated that a single display, keyboard, and pointing device would be required, necessitating an integrated architecture. Deployment schedules continue to evolve to support funding profiles and DSR schedules. The initial daily use of CCLD URET (Build 1) is estimated for 11/01 and Build 2 for 10/02. The benefits analyses of CCLD will drive FAA's decisions for deployment of an ICP or ERATMDST. Currently, the intention is to deploy the initial FCP 12 months after FSD of DSR ICP.
		Activities leading to the development of a specification for the FCP (integrated ICP/DA/TMA) system was initiated in 4/97, with the initial draft specification to be released in 3/99. Operational evaluation of this system will evolve from a basic capability of ICP being provided to the R-Side and Traffic Management Advisor to the D-Side, up to and including integration and similar capabilities available to both D- and R-Sides.

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RECOMMENDATION	INITIATIVE	STATUS[a]
	c. With users and NATCA, FAA will evaluate limited deployment prototypes and will determine if, where, and when it will be possible to implement components of those prototypes to provide benefits before DSR implementation. (Move from prototype to local operational deployment.)	FAA's development strategy for ICP has been focused on the URET operational prototype. The initial URET technology transfer from MITRE/CAASD to FAA and its contractors is complete. MITRE/CAASD is continuing to refine the detailed technical requirements for key areas of the ICP capability; these areas include Interfacility Automation (IFA), automated coordination, and conflict probability prediction.
		The implementation of ICP was planned as the first Pre-Planned Product Improvement (PPPI) for DSR, 6 months following FSD. A formal investment decision (JRC) was planned for full-scale implementation of ICP by 3/98 but was deferred to accommodate FFP1 planning. Cost, benefit, schedule, and technical requirements baseline data are being collected to support a decision for ICP. Most recent planning calls for URET CCLD as part of the FFP1 initiative. With the establishment of a System Program Office (SPO) to manage the CCLD FFP1, the direction after URET CCLD Build 2 is still evolving. Options would include a nationally deployed DSR ICP or FCP.
		Preliminary benefits analyses are based on limited experimentation at Indianapolis ARTCC. Baseline measures for ATM with and without automation decision support tools are being developed.
		The URET operational prototype was installed at all sectors at ZID and ZME by 1/98. It was expanded from 8 hours a day, 5 days per week, to 12 hours per day. It is intended to be available 16 hours a day, 5 days per week. The initial goal of 16 by 7 will be dependent on funding availability. Daily use of URET began at ZID in 9/97 and ZME in 11/97.
	d. Implement components of conflict probe prototypes to provide benefit before DSR implementation. (Move from local deployment to national deployment.)	FAA's deployment strategy for ICP has been focused on the URET prototype. User acceptance and display refinement are more advanced for the URET system than other candidate systems. A URET implementation viability assessment was completed in 12/96. MITRE/CAASD is continuing to refine the detailed technical requirements for key areas of the ICP capability; these areas include IFA and conflict probability prediction.

(continued)

RECOMMENDATION	INITIATIVE	STATUS[a]
		Options explored for the ICP implementation were using URET software, re-architecting URET as an integral part of DSR, or re-using portions of various systems and prototypes (e.g., CTAS, UPR, URET) to achieve DSR ICP requirements. The decision was made to use URET.
		In 3/98, FAA began evaluation of an RTCA/ATA recommendation to deploy URET “as is” to five additional centers. The stand-alone URET will continue to be used at ZID and ZME and because of the DSR schedule, will not be deployed to additional ARTCCs. The CCLD FFP1 initiative plans to deploy URET CCLD to seven ARTCCs to permit a robust evaluation of user benefits and support of free flight.
		A formal investment decision (JRC) on the full-scale implementation of ACD-D was scheduled for 3/98 but deferred pending a recommended position on FFP1. Data being collected for the JRC include costs, benefits, schedules, and technical requirements baseline information.
		The URET operational prototype was installed “as is” to all sectors at ZID and ZME in 1/98. It expanded to 12 hours, 5 days per week, in 4/98 and is to evolve to 16 hours per day, 5 days a week. Daily use began at ZID in 9/97 and ZME in 11/97. Daily use in at least three areas was to be achieved at both ZID and ZME by 9/98. As of 6/98, all sectors at ZID are approved for use, and four of five areas at ZME have been approved. Well over half the controllers have been trained and the remainder will be trained by 12/31/98. A critical functionality, two-way Host interface, is scheduled for delivery to the WJHTC in 10/98 and the ARTCCs in 12/98.
		The daily-use URET system will continue to be used to gather data to support operational development of the FSD ICP system. The URET evaluation systems will also support benefits data collection as well as controller evaluation of CHI and functionality.

RECOMMENDATION	INITIATIVE	STATUS[a]
22. FAA should support the Meteorological Data Collection and Reporting System (MDCRS) to enhance the quality and quantity of real-time aircraft-reported weather information.	a. National Weather Service (NWS) review of processing options for aircraft meteorological data.	The NWS review of processing options is complete. The ARINC Corporation will continue to decode the ACARS data from the airlines and process it into the MDCRS format. The data are processed on a platform called the ATS server, which replaced the TANDEM processor. Deployment was completed 7/97.
	b. Memorandum of agreement on cost sharing between FAA and NWS.	The establishment of a memorandum of agreement on cost sharing between FAA and NWS has not been formalized. However, under the current ARINC contract FAA and NWS have equally shared the cost of developing the new ATS server. The ATS server processes and sends MDCRS data via communication circuits to the NWS gateway.
	c. Industry-sponsored user education program to solicit participation by more aircraft.	ARINC continues to sponsor user education programs to solicit participation from airlines. Two additional airlines are expected to provide meteorological data in 1998.

RECOMMENDATION	INITIATIVE	STATUS
29. Additional expansion of the NRP below FL 290 should be explored. Accelerate modeling and analysis efforts needed to facilitate NRP's continued expansion.	a. Form a working group consisting of industry, NATCA, and FAA to identify methods to accommodate user-preferred routing below FL 290.	Working groups have been formed and are meeting.
	b. Conduct modeling and simulation to identify impact of increased user-preferred routing below FL 290. Evaluate airspace capacity and demand, sector design, controller workload, communication, and information requirements.	MITRE/CAASD study complete.
	c. Build on FAA/NATCA composite direct route document with fixes for direct routing at lower altitudes.	Deferred until enhancements to program are completed in RTCA recommendation 5.

RECOMMENDATION	INITIATIVE	STATUS[a]
32. Begin rule-making to remove the 250-knot speed limit for departing aircraft at elevations below 10,000 feet in Class B airspace.	a. Using existing laboratory simulation capabilities, evaluate removing the 250-knot restriction, assessing capacity, environmental (noise), safety and workload issues. •Initial simulations	The field test at Houston has provided partial validation of the operational feasibility of modifying or removing the 250-knot speed limit for departing aircraft. The results of the preliminary evaluation are, for the most part, positive. Even where metrics indicated some effects on the areas examined, the results may be considered positive in the sense that the test did not produce any conclusive indication that modifying the speed restriction is unworkable.
	b. Field test removal of restriction at selected airports.	The field test at Houston Intercontinental began 6/26/97. On the basis of preliminary evaluation, FAA is recommending that the test be extended to a second site.
	c. Remove restriction incrementally.	Pending completion of field testing.

[a]The status of each initiative is as described by the responsible FAA official.

Source: FAA.

Proposed Operational Capabilities for Flight 2000, Renamed the Free Flight Operational Enhancement Program

This table describes the proposed operational capabilities contained in the roadmap for the revised Flight 2000 program that was developed by RTCA and was submitted in September 1998 to FAA for approval. A decision is expected in fall 1998. Over 70 operational capabilities were reviewed using four criteria[1] and 9 were selected as essential for the successful evolution of the NAS. The revised demonstration is tentatively planned for implementation between 1999 and 2004. Each of the nine capabilities is described below, including the expected operational benefits and the locations where deployment is planned.

Operational capability	Description	Expected operational benefits	Locations[a]
Flight Information Service (FIS) for Special Use Airspace (SUA) Status, Weather, Wind-Shear, Notice to Airmen (NOTAM), Pilot Reports (PIREP)	Use FIS to provide pilots and controllers with current and forecasted weather and weather-related information as well as the status of SUAs; the information will be displayed graphically to the pilot	•Increased availability of flight services •Increased timeliness and quality of data on weather and system status •Increased access to airspace •Reduced flight times and distances	Alaska
Cost-Effective Controlled Flight Into Terrain (CFIT) Avoidance Through Graphical Position Display	Provide a cost-effective terrain database and display in the cockpit	•Increased pilot awareness of surrounding terrain •Reduction in the CFIT rate •Increased access to low-altitude airspace where terrain-imposed restrictions exist	Alaska
Improved Terminal Operations in Low-Visibility Conditions	Use Automatic Dependent Surveillance-Broadcast (ADS-B)[b], Cockpit Display of Traffic Information (CDTI), and Traffic Information Service (TIS) during low-visibility approach operations so that the flight crew will be better able to identify and judge the distance and speed of the aircraft they are following	•Improved ability of crew to accomplish approaches at lower minimums •Ability of flight crew to maintain better spacing during Visual Flight Rules (VFR) and Instrument Flight Rules (IFR) approaches •Increased access to airports •Increased arrival rates •Reduced arrival and departure delays •Increased predictability of arrival times •Increased flexibility of arrival scheduling	Ohio Valley
Enhanced See and Avoid	Provide traffic information electronically to the cockpit using ADS-B, and CDTI, and TIS or Traffic Information Service-Broadcast (TIS-B)	•Improved ability of pilots to maintain awareness of surrounding traffic, even in instrument meteorological conditions •Increased safety	Ohio Valley, Alaska

(continued)

[1]In general, under these criteria (1) industry and FAA must address all aspects of modernization to be successful in moving toward free flight; (2) expected benefits are the major reason for implementing a given capability; (3) the capability does not interfere with or slow down any near-term activities; and (4) the risks associated with operational capabilities that require the integration of multiple communication, navigation, and surveillance technologies should be addressed.

Operational capability	Description	Expected operational benefits	Locations[a]
Enhanced Operations for En Route Air-to-Air	Evaluate the use of Cockpit Display of Traffic Information (CDTI) and Automatic Dependent Surveillance-Broadcast (ADS-B) to allow delegation of separation authority to the cockpit	•Increased access to airspace •Reduced flight delays and distances flown •Increased predictability of flight times and distances flown •Increased flexibility in routes flown	Ohio Valley, Alaska
Improved Surface Navigation	Equip aircraft and ground vehicles with a moving-map display that allows pilots and vehicle operators to “see” all other traffic	•Improved ability of pilots and vehicle operators to navigate the airport surface, including the ability of pilots to taxi using augmented Global Positioning System (GPS) navigation and maps and, in extremely low-visibility conditions, using Local Area Augmentation System (LAAS) •Reduced runway incursion incidents •Reduced taxi delays •Increased predictability of taxi times	Ohio Valley, Alaska
Enhanced Airport Surface Surveillance for the Controller	Equip aircraft and ground vehicles in the airport movement area with ADS-B using augmented GPS-derived positions	•Enables local and ground controllers to monitor the positions and speeds of all vehicles on the airport surface, even in low-visibility conditions •Reduced runway incursion incidents •Reduced taxi delays •Reduced arrival delays •Increased predictability of taxi times •Increased departure/arrival rates	Ohio Valley, Alaska
Automatic Dependent Surveillance-Broadcast (ADS-B) for Surveillance in Non-Radar Airspace	•Use ADS-B to provide additional surveillance coverage and fill gaps in radar coverage •Examine how ADS-B could eventually replace some radars	•Improved controller ability to provide separation services and reduced reliance on procedural separation •Increased access to airspace •Increased arrival and departure rates •Reduced flight delays and distances flown •Increased predictability of flight times and distances flown •Reduced deviations from the intended route •Increased flexibility in the routes flown •Increased safety	Alaska
Establish ADS-B Based Separation Standards	•Integrate ADS-B data with radar and conflict alert to determine if separation standards can be reduced •Ultimately integrate ADS-B with advanced decision support automation	•Increased efficiency •Maintained or increased safety	Alaska

(Table notes on next page)

[a]Selected sites for demonstrations in the Ohio Valley include Memphis, Tennessee; Wilmington, Ohio; Louisville, Kentucky; Scott Air Force Base (Belleville, Illinois); and Nashville, Tennessee. Additionally, Alaska was chosen as a second location primarily for the demonstration of the safety aspects associated with the selected operational capabilities.

[b]ADS-B avionics periodically broadcast aircraft position information derived from GPS augmentations to enable other aircraft and ground systems to perform surveillance of equipped aircraft on the airport surface or in terminal and en route phases of flight.

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