United States General Accounting Office

GAO

Report to the Chairman, Subcommittee on Transportation, Committee on Appropriations, House of Representatives

May 1988

MICROWAVE LANDING SYSTEMS

Additional Systems Should Not Be Procured Unless Benefits Proven

GAO/RCED-88-118

GAO United States
General Accounting Office
Washington, D.C. 20548

Resources, Community, and
Economic Development Division

B-225281.2

May 16, 1988

The Honorable William Lehman
Chairman, Subcommittee on
Transportation
Committee on Appropriations
House of Representatives

Dear Mr. Chairman:

This report is in response to your request to conduct continuing reviews of the Federal Aviation Administration's (FAA) National Airspace System plan. This report addresses FAA's management of the development and acquisition of a precision approach and landing system, the microwave landing system.

As agreed with your office, unless you publically announce its contents earlier, we plan no further distribution of this report until 7 days from the date of this letter. At that time, we will send copies of this report to the Secretary of Transportation; the Administrator, Federal Aviation Administration; and the Director, Office of Management and Budget. Copies are also being made available to other interested parties.

This work was performed under the direction of Kenneth M. Mead, Associate Director. Major contributors are listed in appendix VI.

Sincerely yours,

J. Dexter Peach
Assistant Comptroller General

Executive Summary

Purpose

Important parts of our national airspace system (NAS) are the precision landing systems which allow aircraft equipped with the necessary electronic hardware (avionics) to land in conditions of limited visibility, thereby increasing the time an airport can operate during poor weather. The current precision landing system, the instrument landing system (ILS), is scheduled to be replaced with the microwave landing system (MLS) as part of the Federal Aviation Administration's (FAA) ambitious effort to modernize the nation's air traffic control system—known as the NAS plan.

The Chairman, Subcommittee on Transportation, House Committee on Appropriations, asked GAO to review FAA's implementation of the NAS plan. As part of this effort, GAO reviewed the MLS program, addressing the following objectives:

- assess the justification and requirements for a new precision landing system to replace ILS and determine and analyze ILS improvements since MLS was justified,
- determine whether FAA has adequately demonstrated MLS' potential operational and economic benefits, and
- determine the reasonableness of FAA's MLS siting strategy.

Background

Precision landing systems are comprised of (1) ground units located adjacent to airport runways and (2) avionics equipment on aircraft. When approaching an airport, a pilot, using the avionics, follows an indicated course and angle of descent down to a point where the runway becomes visible.

The standard precision landing system for over 40 years has been the ILS. In the 1970s, the federal government, with the aviation community's support, selected MLS as the primary precision landing system for military and civilian use. MLS has also been selected as the international standard to replace ILS.

FAA plans to spend about $1.6 billion on 1,250 MLSs, while the Department of Defense plans to spend $357 million on 405 MLSs. Further, installing MLS avionics on civilian aircraft—a prerequisite for using the ground systems—will cost about $5.1 billion more than using ILS.

Installation of the first of 178 MLSs was scheduled by FAA to begin in January 1986. However, primarily because of software development problems, installation is 27 months behind schedule.

FAA had planned to buy another 500 MLSs early in fiscal year 1987. However, the Congress denied funds for this purpose for fiscal year 1987 because of MLS development problems. For fiscal year 1988 the Congress denied funds to procure MLSs pending operational tests and an implementation strategy review.

Results in Brief

MLS was justified 19 years ago because of ILS' reliability and precision landing capability limitations. However, through improvements to ILS, FAA has largely addressed concerns about these limitations, though FAA has not determined how these improvements and air traffic growth, which has been lower than predicted, affect the need for MLS.

MLS offers potential operational and economic benefits in cases where ILSs cannot be used because of siting or visibility limitations. MLS' specialized approach capabilities and various descent angle features also may increase airport capacity and reduce flight delays. However, FAA has not adequately demonstrated such benefits, nor addressed safety and reliability questions using MLS in challenging operational environments. The Air Transport Association, which represents most major U.S. airlines, believes there is little incentive for its members to install MLS avionics on their aircraft until MLS' benefits are adequately demonstrated.

Since 1984 FAA has twice changed the locations to receive the first MLSs because it has developed new selection criteria for choosing these sites.

Principal Findings

ILS Is a Much Improved System

In 1969, when MLS was first justified, concerns existed about ILS' reliability and the limitations on the number of radio channels and frequencies available to it. FAA has generally addressed these concerns. For example, ILSs are now more reliable because tube-type systems have been replaced with solid-state systems. Overcoming the problem of radio frequency limitations has included assigning the same radio frequency rather than different frequencies to ILSs at opposite ends of the same runway; this frees frequencies for more ILSs.

MLS was also justified because large increases in air traffic volume were forecast. However, this growth has been less than expected, with flights that might have used precision guidance to land in 1980 increasing to only about half what was forecast in 1969. Meanwhile, according to an FAA official, FAA has not determined what air traffic volume warrants using MLS instead of ILS.

FAA still plans to replace ILSs with MLSs even though it has not reassessed its plan by recognizing (1) ILS improvements and (2) lower than forecast air traffic growth. In the interim, the Air Transport Association believes that ILS meets most of its precision landing system needs. It has recommended that FAA retain ILS as the United States' primary precision landing system, and MLS become the standard secondary system worldwide in airports where ILS cannot meet user needs.

MLS Potential Benefits Not Adequately Demonstrated

MLS offers potential operational and economic benefits. However, these benefits are contingent on several factors, including the success with which it can be integrated into the actual air traffic control environment.

FAA recognized the importance of testing MLS in the airport environments in which it is to be used. However, because of problems and delays, program costs increased and FAA entered production after limited testing of MLS units not built to FAA specifications. Thus, the potential benefits as well as the system's safety and reliability remain in question. For example, testing special airport approaches made possible with MLS has been conducted only in a nonoperational environment.

For fiscal year 1989, FAA requested $20 million to initiate purchasing MLSs and develop the avionics necessary to demonstrate MLS' potential benefits in preparation for a second procurement.

FAA is also developing plans to test MLSs at Washington's National Airport and New York's LaGuardia Airport. How comprehensive these tests will be has not been determined.

FAA's MLS Siting Strategy Needs Reassessment

Since 1984, FAA has revised its selection criteria for choosing where MLSs will be sited. Initially, the first 172 MLSs were to be installed at large and medium airports—defined on the basis of passenger traffic activity—and their connecting airports. FAA revised the locations (increased to 178) because some were not cost-beneficial and some others had higher priorities. Most recently, though, FAA has chosen airports where MLS may provide increased operational benefits; these are selected on the basis of air carriers' verbal commitments to equip their aircraft with MLS avionics. The results of this method, however, have been questioned by the Department of Transportation's Inspector General, who found that MLS did not have the amount of user support FAA thought existed.

Recommendations

GAO recommends that the Secretary of Transportation require FAA not to proceed with the planned second MLS procurement unless MLS' potential operational and economic benefits have been adequately demonstrated. This should include comparing the results of testing MLS in challenging airport environments to the much improved ILS and recognizing current and expected air traffic growth.

Interim actions to be taken are detailed in chapters 4 and 5.

Agency Comments

GAO discussed the matters in this report with FAA officials and incorporated their comments where appropriate. However, as requested, GAO did not obtain official agency comments on a draft of the report.

Contents

Abbreviations

ALPA	Air Line Pilots Association
AOPA	Aircraft Operators and Pilots Association
ATA	Air Transport Association of America
DOD	Department of Defense
DOT	Department of Transportation
FAA	Federal Aviation Administration
GAO	General Accounting Office
ICAO	International Civil Aviation Organization
IATA	International Air Transport Association
ILS	Instrument Landing System
IMTEC	Information Management and Technology Division
MLS	Microwave Landing System
NAS	National Airspace System
NASA	National Aeronautics and Space Administration
NTSB	National Transportation Safety Board
OMB	Office of Management and Budget
RAA	Regional Airline Association
RCED	Resources, Community, and Economic Development Division

Introduction

The Department of Transportation's (DOT) Federal Aviation Administration (FAA) is responsible for operating a national airspace system that moves air traffic safely and expeditiously. An important part of this system is the precision landing equipment located adjacent to a runway. This equipment allows aircraft that have the necessary electronic hardware (avionics) to land in conditions of limited visibility. Without such equipment, FAA generally does not permit aircraft to land under certain limited visibility conditions. Precision landing equipment thus increases the time an airport can operate during poor weather conditions. Of the over 29 million landings in the United States reported by FAA air traffic control towers in 1986, about 7 million, or 24 percent, used precision landing equipment.

The standard precision landing system for over 40 years has been the instrument landing system (ILS). In the early 1970s, the federal government, with the support of aviation community representatives, selected a microwave landing system (MLS) as the primary precision landing system for military and civilian use.

In December 1981, FAA embarked on an ambitious effort to modernize the nation's air traffic control system. The modernization plan is known as the National Airspace System (NAS) plan; MLS is one of the plan's 12 major system projects. FAA plans to procure 1,250 ground-based MLSs at a total estimated current dollars cost of about $1.6 billion.[1] The Department of Defense (DOD) also plans to procure through FAA another 405 ground-based MLSs at an estimated cost of about $357 million. Civilian U.S. aviation users are expected, according to a contractor conducting an MLS cost-benefit study for FAA, to spend about $15.2 billion in current dollars from 1988 through the year 2004 to equip their aircraft with the necessary on-board avionics.[2]

MLS has also been selected by the International Civil Aviation Organization (ICAO) as the international standard to replace ILS. In addition to the 1,655 MLSs being procured by FAA and DOD, foreign countries are expected to buy about 360 ground-based MLSs. Thus, FAA and DOD procurements represent about 80 percent of the total MLSs being purchased.

[1] Current dollars refers to the cost to be incurred in the years that equipment is purchased.

[2] According to an FAA contractor, the last ground-based ILSs will be decommissioned, i.e., not operational, by the year 2004. Users, however, would still incur an estimated cost of $10.1 billion through 2004 to equip aircraft with ILS avionics if MLS is not installed and ILS remains the standard precision landing aid. Thus, the additional cost of MLS to civilian U.S. aviation users is about $5.1 billion.

Precision Landing Systems

According to FAA, precision landings are safer than nonprecision landings because of the lateral, vertical, and distance guidance information provided by precision landing systems. Ground-based precision landing systems send signals that enable pilots to follow an indicated course and angle of descent down to a point where the runway becomes visible. The landing visibility required depends on the precision landing equipment being used on the ground and in the aircraft.

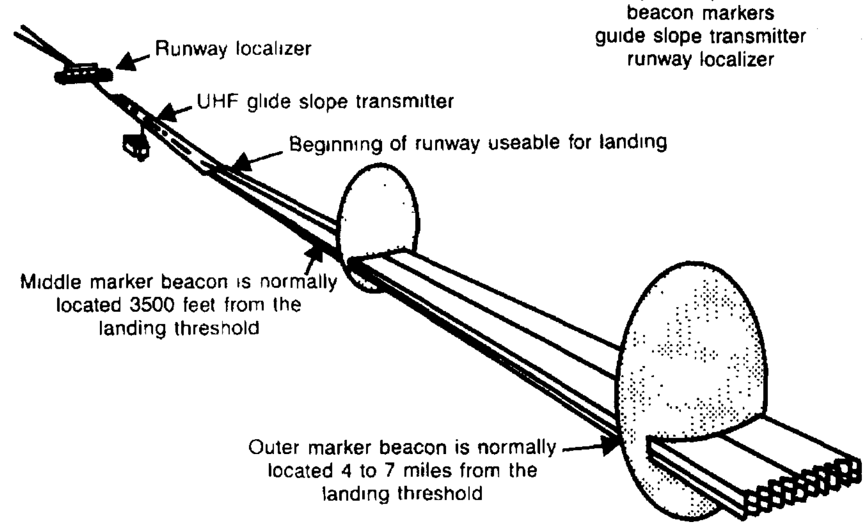
Precision approaches are categorized by the distance and elevation that an aircraft can safely descend without visual reference to the runway. If the pilot cannot see the runway at the required minimum distance and elevation, he or she must abort the landing. Precision approaches with Category I equipment allow an aircraft to descend to an altitude of not less than 200 feet when visibility is greater than 1/2 mile or the runway visual range (the horizontal distance a pilot can see down a runway from the approach end) is a minimum of 1,800 feet. Category II equipment allows an aircraft to descend to an altitude of not less than 100 feet when the runway visual range is a minimum of 1,200 feet. Category III equipment does not require a minimum altitude. Instead, depending on the support equipment used, three different minimums of runway visual range may be used: 0 feet, 150 feet, or 700 feet.

Instrument Landing System

An ILS (see figure 1.1) consists of three basic ground components: (1) a localizer, which generates a signal indicating a course down the runway centerline; (2) a glide slope transmitter, which generates a signal (adjusted 3 degrees above horizontal) indicating the optimum angle of descent to the runway (vertical guidance); and (3) two or three marker beacons or distance measuring equipment (DME) used instead of one specified beacon, each of which generates a signal that indicates the aircraft's distance from the point where it should touch down on the runway. When approaching an airport, the pilot turns on the ILS receiver and follows the indicated course and angle of descent down to a point where the runway becomes visible.

As of May 1987, FAA had 773 ILSs at 531 airports and another 24 installations were planned. When these planned installations are completed, FAA will have 797 ILSs at 535 airports. In addition, according to FAA's Aviation Standards National Field Office records as of May 1987, 183 ILSs were owned by DOD and about 75 ILSs were privately owned in the United States.

Figure 1.1: Layout of ILS Ground Stations



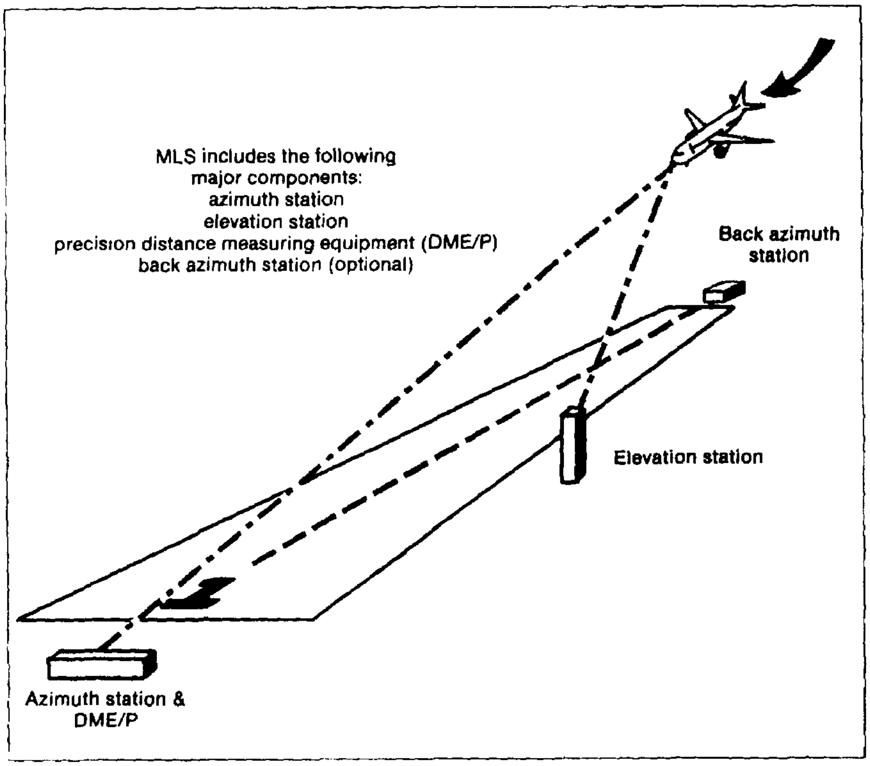
Source Federal Aviation Administration

Microwave Landing System

An MLS also consists of three standard ground components and one optional component. The standard components are: (1) an azimuth station, which is analogous to the ILS localizer but with a wider proportional guidance coverage (up to plus or minus 60 degrees); (2) an elevation station, which is analogous to the glide slope transmitter except that it provides a wide selection of descent angles (up to 15 degrees); and (3) precision distance measuring equipment, which shows the aircraft's distance from the point where it should touch down on the runway and is six times more accurate than the conventional distance measuring equipment used with ILS. The optional component is a back azimuth station that provides lateral guidance for missed approach and departure navigations. These components are illustrated in figure 1.2.

As described in chapter 3, FAA has undertaken various steps to demonstrate MLS' capabilities using commercially built MLSs. However, no MLS ground units built to FAA specifications have been tested. In addition, FAA has not adequately demonstrated MLS benefits, nor has it addressed the safety and reliability questions that accompany using MLS in challenging operational environments.

Figure 1.2: Layout of MLS Ground Stations



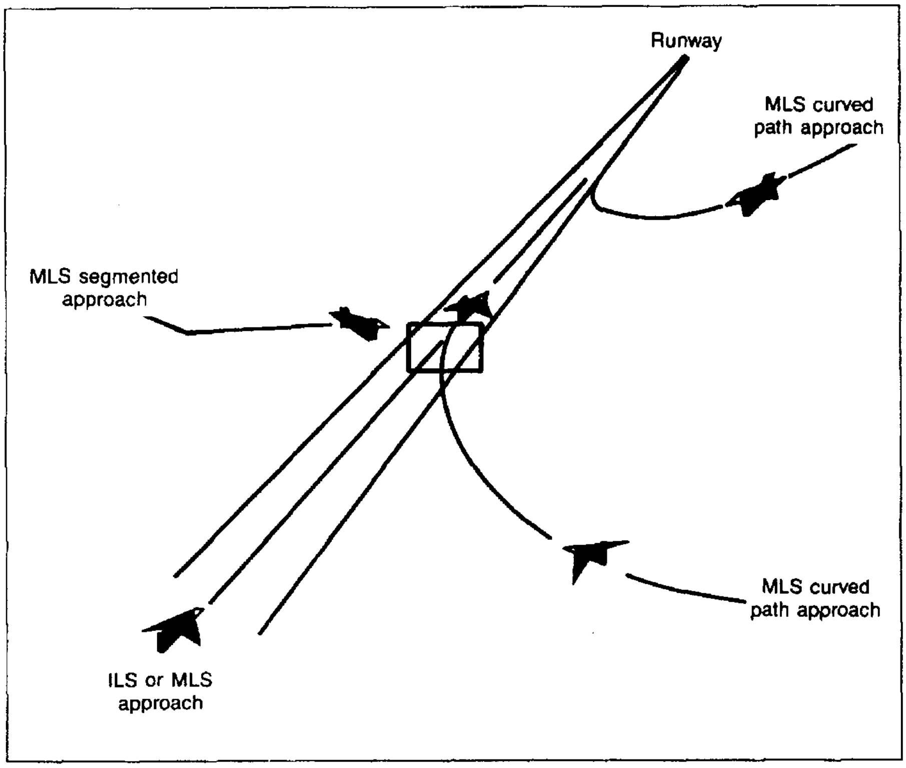
Potential Differences Between ILS and MLS

ILS provides a single approach path with up to a 3-degree angle of descent. Conversely, MLS can provide multiple approach paths, and various angles of descent. The various directions of approach result from MLS' curved and segmented approach capability, while the various descent angles are generated by the glide path provided by MLS' elevation station.

According to an FAA official, MLS' curved and segmented approach capability may permit lining up aircraft with different approach speed characteristics on different approach paths (i.e., separating turboprop aircraft from the larger turbojet aircraft).

MLS' various angles of descent, by using steep approach angles, may make it possible for certain aircraft to land on short runways or runways with high ground in the approach path. MLS may reduce aircraft noise in certain locations during periods of poor weather conditions by permitting aircraft to continue to follow approach paths over less populated areas. And MLS may provide some approaches to heliports not possible with ILS. Different approach paths are illustrated in figure 1.3.

Figure 1.3: Multiple Approach Paths to Runway



Further, there are some locations where a precision landing system is justified, but an ILS cannot be sited because of terrain or obstacles in the approach path. Siting MLSs at those locations may provide for operational benefits. For instance, mountains prohibited siting an ILS at Valdez, Alaska. The precision approach requires a minimum glide path of 6.2 degrees to clear the terrain under the approach path. The ILS provides a 3-degree maximum glide path. The city of Valdez purchased a commercial MLS that was commissioned by FAA in 1982.

Similarly, sometimes the ILS localizer cannot be located on the runway centerline at the end of the runway extended but is sited to the side of the runway. This requires raising the visibility requirement for landing by 50 feet. For example, aircraft that would normally be permitted to land if the runway is visible at 200 feet would be permitted to land only if visibility existed at 250 feet above ground level. Siting the MLS azimuth station (which is analogous to the ILS localizer) on the runway centerline extended may eliminate this 50-foot penalty and permit landings to continue in more reduced visibility.

Another potential benefit provided by MLS concerns the missed approach area—the area required for an aircraft to safely abort a landing. If there is an obstacle such as a building in the missed approach area, an aircraft may have to abort its landing sooner and at a higher altitude than normal. The closer the obstacle is to the runway end or the taller it is, the further away from the airport and the higher up an aircraft must be when a decision is made to abort a landing to avoid the obstacle.

FAA's missed approach area requirement has restricted the use of ILSs at some locations because of obstacles in ILS' missed approach area. Depending on the location and height of the obstacle(s) in relation to the runway end, an MLS azimuth station on the runway end opposite from the approach end, may provide missed approach areas not provided by ILSs, thereby permitting an aircraft using MLS to land in instances where it could not land using ILS.

International MLS Agreement

In 1979, ICAO adopted MLS as the replacement for ILS. According to the present international agreement, as amended in 1987, ILSs will be eliminated from international service by January 1, 2000.

ICAO is a United Nations organization established under a written convention on international civil aviation agreed to by 26 countries in 1947. Over the years ICAO's membership has grown, and in 1986 numbered 156 countries.

ICAO has established air navigation plans by region; these set forth the facilities, services, and procedures required for international air navigation. The plans identify 101 runways in the United States and its territories used by internationally-scheduled airlines on a regular or alternative basis where the United States is committed to install MLSs. The ICAO has designated 31 of these as Category II runways, meaning that the MLSs to be installed must be Category II.

Management of MLS Program

The management of the acquisition phase of the MLS program is set forth in FAA Order 1810.1D dated July 13, 1985, "Major Systems Acquisitions," which establishes policy and procedures for management of major systems acquisitions. Under this order, a program manager is assigned the complete responsibility, authority, and accountability for a major system acquisition from the development stage through the production and installation of the system. Program managers are accountable to the NAS program director through the appropriate supervisory channels. The NAS program director is accountable to the FAA Administrator.

An MLS program manager was designated in 1978, and as of November 1982 organizationally reported to the director, Program Engineering and Maintenance Service, who, in turn, reported to the NAS plan's program director. In August 1987, the Program Engineering and Maintenance Service was renamed the Program Engineering Service and the MLS program manager reported to the Service's Navigation and Landing Division Manager, a lower level official.

The program manager's responsibility, authority, and accountability as well as general program goals, schedules, and anticipated resource requirements are defined in the MLS program manager's charter. According to the charter, the program manager manages the MLS program by assigning to or coordinating work activities with line organizations and functional staffs. However, the program manager does not have direct line supervision over the people to whom he or she assigns work activities. (See app. I for a chart of the FAA organizations involved in the MLS program.)

MLS Program Status

As previously discussed, FAA plans to buy 1,250 MLSs. The first contract for 178 MLSs is 27 months behind schedule, primarily because of software problems. The second proposed procurement has not been awarded because the Congress has not appropriated funds for this procurement. Funds have not been appropriated because of delays in the first production contract and pending additional operational tests and a review of FAA's MLS implementation strategy.

FAA awarded a contract to Hazeltine Corporation in January 1984 for 172 Category I MLSs, with options to purchase 36 more. FAA exercised one option for six additional Category I MLSs, resulting in a total of 178 MLSs costing about $79 million. Installation of the first unit was scheduled for January 1986. According to an FAA official, the first unit would not be installed on site until April 1988, 27 months behind schedule. FAA attributes the delay primarily to its and the contractor's belief that the software for the contractor's commercial MLS could be slightly modified to meet FAA's production specifications.[3] This has not been the case. Both the software and the hardware had to be redesigned by the contractor to meet specifications.

FAA recognized that the contractor was behind schedule on system software requirements during an MLS status review conducted at the contractor's plant during August and September 1985. In order to resolve the software development problems and because it did not have the necessary in-house expertise, the contractor subcontracted some of the software development in March 1986.

FAA planned to initiate a second procurement of 500 MLSs early in fiscal year 1987. According to FAA, as of September 28, 1987, the second procurement will have not only Category I, but also include 6 Category II and 55 Category III MLSs. Pilots using a Category II or III precision landing system could reach a point during the approach for landing where they will not be able to abort the landing. Therefore, the systems must be guaranteed to work to ensure a safe landing. Category II and III systems have more stringent integrity and continuity of service requirements than Category I systems. These requirements are to be met by incorporating system redundancy into the MLS design for the second procurement. According to the Director of DOT's Transportation Systems Center, producing Category II and III equipment presents an added technical challenge in both system design and development.

DOD also planned to acquire 194 Category I MLSs in the second FAA procurement. As opposed to FAA's MLS procurement, which includes Category II and Category III units, all of DOD's 405 ground-based MLSs will be Category I. Thus, DOD's systems do not include the cost of components that must be added to achieve Category II and Category III capabilities.

The House and Senate Committees on Appropriations, noting schedule delays on the first MLS production contract, eliminated the $43 million requested by FAA in fiscal year 1987 for the initial 56 units of the second procurement. In addition, the Committee of Conference directed that no further procurement activity be initiated until the House and Senate Appropriations Committees have had the opportunity to hold hearings to determine the status of the MLS program and have approved funding to procure additional systems.

[3]As of January 1, 1986, the contractor had installed eight MLSs not built to FAA specifications in the United States, Canada, the United Kingdom, and Italy.

FAA also requested funding for the second procurement in fiscal year 1988. Again, the Committee of Conference denied the request, pending additional operational tests and a review of FAA's MLS implementation strategy. The Committee, however, did allow about $3.5 million for such MLS tests.

For fiscal year 1989, FAA requested $20 million to (1) develop avionics to demonstrate MLS' potential benefits including curved and segmented approaches and (2) initiate design efforts by two contractors to produce Category II and III MLSs in preparation for a second procurement of 375 MLSs for fiscal years 1990 through 1992. FAA also requested $846,000 for simulation studies to evaluate the feasibility of new air traffic control and flight deck procedures required for curved approaches, missed approaches, and departures. FAA anticipates another $11 million will be required for fiscal years 1990 through 1993 to continue developing these procedures.

Objectives, Scope, and Methodology

The MLS program is part of FAA's NAS plan, a comprehensive $15.8 billion endeavor to consolidate, modernize, and automate air traffic control facilities and services. In June 1983, the Chairman of the House Appropriations Subcommittee on Transportation asked us to monitor and periodically report on all aspects of FAA's NAS plan implementation. This report is one of a planned series of reports and testimonies responding to that request.[1]

The objectives of our review were to (1) assess the justification and requirements for a new precision landing system to replace ILS and determine and analyze what improvements have been made to ILS since MLS was justified, (2) determine whether FAA has adequately demonstrated MLS' potential operational and economic benefits, (3) determine the reasonableness of FAA's MLS siting strategy, and (4) ascertain industry and user association views concerning ILS and MLS.

Our review was performed primarily at FAA headquarters in Washington, D.C. We interviewed the MLS Program Manager as well as other officials in FAA's

- Program Engineering Service, which is responsible for the installation of ILSs and the engineering, design, production, and installation of MLSs;

[1]See p. 71 for a list of other NAS-related reports and testimonies.

- Office of Flight Standards, which is responsible for developing aircraft procedures required to use MLSs and authorizing runways and aircraft for Category II and Category III ILS operations;
- Office of Program and Regulations Management, which is responsible for determining where to locate ILSs and MLSs; and
- Air Traffic Operations Service, which is responsible for determining how MLS will be used at individual airports.

In addition, we reviewed pertinent legislation; congressional hearings and reports; and FAA policies, criteria, and procedures. We also considered a February 6, 1987, MLS Program Assessment performed by DOT's Research and Special Program Administration's Transportation Systems Center for DOT's Assistant Secretary for Administration.

To assess the justification and requirements for MLS and determine what improvements have been made to the ILS since the MLS requirements were written, we interviewed various FAA officials. These included representatives from six of FAA's nine regional offices—New England, Eastern, Southern, Central, Western Pacific, and Great Lakes—and the FAA Technical Center at the Atlantic City airport, New Jersey; officials in the Navigation and Landing Division's Current Landing System Program responsible for monitoring and installing ILSs; and officials in the Spectrum Engineering Division responsible for assigning and managing equipment signal frequencies. We also reviewed FAA documentation on ILS maintenance, siting criteria, contracts for glide slope transmitters and the MLS. We reviewed ILS' safety record by interviewing National Transportation Safety Board (NTSB) officials and reviewing NTSB aircraft approach and landing accident reports. To ascertain whether the increase in air traffic growth predicted in DOT's 1969 Air Traffic Control Advisory Committee report has materialized, we interviewed an official from FAA's Office of Aviation Policy and Plans responsible for forecasting air traffic and reviewed FAA reports on actual and projected levels of air traffic.

To address FAA's adequacy in demonstrating MLS' potential operational and economic benefits, we reviewed various FAA reports and a 1977 Radio Technical Commission for Aeronautics report on MLS implementation. We also interviewed FAA regional office officials to determine under what circumstances MLS could be used to provide better precision landing capability than ILS. To determine what adequate testing means, we reviewed Office of Management and Budget (OMB) and DOT guidance on acquiring major systems, two Blue Ribbon Panel reports on operational testing, and an FAA consultant's study on testing selected FAA programs.

We also reviewed FAA's MLS Transition Plan, Implementation Plan, Service Test and Evaluation Program Plan and updates, and its final report on the Service Test and Evaluation Program.

To address the reasonableness of FAA's MLS siting strategy, we reviewed FAA's MLS implementation plan, changes to the plan, and discussed the strategy and the plan with FAA officials. In considering the limited availability of new precision landing systems in recent years, we reviewed FAA's MLS/ILS installation policy and FAA documents concerning procurement and installation of ILSs and MLSs. We analyzed FAA's various siting listings for the first MLSs purchased. Our analysis included reviewing FAA's various implementation strategies for the listings and the changes made to each listing.

To ascertain user views concerning MLS, we interviewed aviation user association personnel or reviewed documentation concerning the Air Transport Association of America (ATA), the Air Line Pilots Association (ALPA), the Regional Airline Association (RAA), the Aircraft Operators and Pilots Association (AOPA), and the International Air Transport Association (IATA). In addition, we conducted a structured telephone survey of 10 of the top 25 U.S. commercial airlines, based on the number of airplane passengers in 1985. Our judgment sample included the 4 largest airlines and 8 of the 10 largest airlines on the basis of passengers who flew on U.S. scheduled airlines. When combined, the 10 carriers we sampled represented about 67 percent of the passengers flying in 1985 on U.S. scheduled airlines.

We also used information from GAO reports concerning ILS, MLS, and major systems acquisitions. A 1978 report on the status of FAA's MLS stated that a large-scale implementation decision was not warranted at that time because of the uncertainty of expected benefits.[5] In that report, we recommended that FAA clearly validate MLS' technical, operational, and economic benefits.

Our April 1985 report on ILS recommended that FAA replace all tube-type ILSs with solid state systems at the earliest possible time.[6] FAA agreed with our report and said it planned to replace all but three of its tube-type ILSs. The remaining three tube-type systems would not be replaced

[5]Status of the Federal Aviation Administration's Microwave Landing System (PSAD-78-149, Oct. 19 1978)

[6]FAA Could Improve Overall Aviation Safety and Reduce Costs Associated With Airport Instrument Landing Systems (GAO/RCED-85-24, Apr. 3, 1985)

because they are located at airports which were scheduled to receive MLS by 1990.

In addition, our March 1987 report on aviation acquisition recognized that FAA had made progress incorporating OMB major system acquisition principles and requirements into its acquisition process and that closer adherence to these principles could reduce cost increases and/or schedule delays.[7] Our April 1987 report to the Chairman, Senate Committee on Armed Services discussed the military requirements for precision landing systems.[8]

In response to FAA initiating a new cost-benefit study in December 1986, we issued a January 29, 1987, letter to FAA's Acting Associate Administrator for Development and Logistics. In the letter, we provided our observations about both the original 1976 MLS cost-benefit study and a limited 1983 update. (See app. II.) FAA said it was considering our observations in conducting the study update.

The 1983 cost-benefit update, which reaffirmed the 1976 study's conclusion that MLS was more cost-effective than ILS, together with operational test results were used, in part, by FAA as justification for the first MLS procurement contract. FAA intends to use the results of the most recent cost-benefit study update to support its position that MLS should replace ILS and as justification when FAA requests support for the planned second MLS procurement, according to an FAA NAS Program Management staff official.

Although not specifically addressed within the context of this report, our findings may have an effect on the results of FAA's most recent cost-benefit study update. Prerequisites to the full-scale production of major systems are (1) the performing of a cost-benefit analysis and (2) the conducting of operational testing. However, though FAA has plans to procure additional MLSs and it has conducted a current cost-benefit study, it has not conducted adequate operational tests of MLS; thus, the validity of the cost-benefit analysis will suffer from the lack of quantifiable objective data.

Before policy makers can make informed decisions concerning a second MLS procurement, as well as the fate of a program now estimated to cost

[7] Aviation Acquisition: Improved Process Needs to be Followed (GAO/RCED-87-8, Mar. 26, 1987).

[8] DOD Acquisition Programs: Status of Selected Systems (GAO/NSIAD-87-128, Apr. 2, 1987).

almost $7 billion in public and private funds, they must have complete and fully analyzed information on improvements to ILS over the last 19 years and the incremental operational and economic benefits of MLS. Such information provides the basis for making cost, efficiency, and other comparisons. Moreover, MLS implementation requires a substantial investment by U.S. aviation users. Therefore, user acceptance of MLS could be important to the program's ultimate success.

Because of their importance to decision makers, we have devoted a chapter to each of the above three issues and one to MLS siting strategy. Chapter 2 discusses the improvements made to ILS over the last 19 years. Chapter 3 discusses FAA's plans and actual testing of MLS. Chapter 4 addresses FAA's MLS siting strategy. Finally, chapter 5 provides current user views toward MLS.

Our work was initially performed from May 1985 to October 1986. Because of the dynamic nature of the MLS program over the past year, including continuing production problems and revisions to the MLS implementation strategy, our work continued through 1987 and is based on information available to us as late as April 1988. We performed our work in accordance with generally accepted government auditing standards.

We discussed with FAA officials, issues concerning procuring additional MLSs and have included their comments in the report where appropriate. However, as requested, we did not obtain official agency comments on a draft of this report.

Requirement to Replace ILS With MLS Needs to Be Reexamined

In 1969, MLS was first justified as the precision approach and landing system of the future because of concern about ILS' capability to meet precision landing system needs. During the intervening 19 years, FAA has generally addressed concerns about ILS as well as new problems that have arisen, resulting in a much improved ILS. However, FAA has not collectively assessed the improvements to ILS or analyzed the impact of less than expected air traffic growth on the need for MLS.

ILS Now Able to Better Satisfy Precision Landing System Needs

Specific concerns about ILS' ability to satisfy precision landing system requirements have been identified in various reports both in 1969 when MLS was first justified and in numerous documents issued throughout the MLS research, development, and procurement process.[1] Among these concerns and FAA's methods of addressing them, which are discussed below, are reliability, radio channel congestion, siting problems, FM radio station signal interference, and limitations on the time airports could operate during poor weather conditions.

ILS Reliability Has Improved

One concern was about ILS' reliability. At the time of the original MLS justification, ILSs were tube-type systems. However, FAA has converted the ILSs to the more inherently reliable solid-state systems and installed solid-state systems where new ILSs have been needed. FAA also has improved ILS reliability by locating certain ILS components together to reduce system outages caused by bad weather, and expects to improve reliability by upgrading the solid-state systems. According to a National Transportation Safety Board official, Board records as of 1987 showed no aircraft accidents caused by faulty ILSs. The DOT Transportation Systems Center also considers ILS to be a safe and reliable system, according to a 1987 report by the Center's director.

Solid-State Systems

According to a GAO report on ILS,[2] FAA began installing solid-state systems in the early 1970s. By the late 1970s, FAA was replacing the tube-type ILSs with solid-state systems. According to FAA's Facilities Master

[1]These reports include the 1969 DOT Air Traffic Control Advisory Committee report on future air traffic control system needs; the 1971 National Plan for Development of MLS prepared by DOT, DOD, and NASA; Radio Technical Commission for Aeronautics reports on the original MLS selection and implementation; and FAA reports, including the 1980 report entitled "An Analysis of the Requirements for and the Benefits and Costs of the National Microwave Landing System."

[2]FAA Could Improve Overall Aviation Safety and Reduce Costs Associated With Airport Instrument Landing Systems (GAO/RCED-85-24, April 3, 1985)

File, as of November 2, 1987, 20 of the over 760 ILSs in service still had tube-type components.

Solid-state systems have substantially improved ILS' reliability by reducing system outages. For example, FAA's data for fiscal year 1985 show that for tube-type and solid-state localizers (which signal an aircraft's location relative to a runway centerline), the mean or average time between unscheduled outages for reasons such as equipment failures, power outages, and bad weather, was 2,658 hours and 4,501 hours, respectively.[3] The average time between outages relating to equipment failures alone was 5,337 hours for tube-type localizers and 8,897 hours for solid-state localizers. Thus, based on average time between outages, solid-state localizers were almost 70 percent more reliable than tube-type localizers.

The newer solid-state localizers have performed better than the older solid-state models. For example, in fiscal year 1985 the newer Category I localizers had an average time between outages for equipment failures of 11,035 hours compared to the 5,391 hours for the older solid-state localizers. This represents over a 100 percent improvement.

Similarly, FAA's fiscal year 1985 data show that the average time between outages for tube-type and solid-state glide slopes (which signal the optimum angle of descent) for all unscheduled reasons was 3,491 hours and 4,636 hours, respectively. The average time between outages for equipment failures alone was 6,300 hours for tube-type glide slopes and 9,939 hours for solid-state glide slopes. Therefore, based on average time between outages for equipment failures, solid-state glide slopes were over 50 percent more reliable than tube-type glide slopes. Additional data showing reliability of ILS components are depicted in appendix III.

Upgrading of Solid-State Systems

FAA also is improving the reliability of its older solid-state ILSs by upgrading them. For example, by the end of 1988, FAA plans to completely replace faulty monitor peak detectors and output amplifiers in 68 of the 262 older solid-state localizers and 59 of the 248 older solid-

[3]One method of demonstrating the reliability of tube-type versus solid-state systems is using the mean time between unscheduled outages for the two systems. The mean time is the average length of time a facility operates between unscheduled outages.

state glide slopes.[4] According to FAA's 1985 report on ILS performance,[5] faulty monitor peak detectors are responsible for a large number of localizer and glide-slope outages, and detector and amplifier replacements should decrease these outages substantially.

In 1986, FAA replaced the transmitter/modulator units in 86 of the 262 older solid-state localizers and 85 of the 248 older solid-state glide slopes. According to an FAA official in the Navigation and Landing Division's Current Landing System Program, FAA also plans to improve the older type solid-state glide slopes by installing modified solid-state localizer modulators.[6] These equipment upgrades are intended to reduce system outages, thus improving equipment reliability.

Integral Monitoring

Since MLS was selected to replace ILS as the precision landing system of the future, one shortcoming attributed to ILS has been the high number of system outages caused by bad weather. This reliability problem was significant with respect to the ILS glide slope, because two glide-slope monitors were located away from each glide slope, exposing them to bad weather. However, since MLS was justified, FAA has physically located one of the monitors adjacent to the glide slope—a process FAA calls integral monitoring. This location of the monitor has the effect of protecting it from the elements and making the monitor less susceptible to bad weather. In addition, the most recently procured glide slopes have both monitors physically located with the glide slopes.

FAA's use of integral monitoring with the glide slope, beginning in 1970, has reduced weather-related glide-slope outages. For example, in fiscal year 1985, there were 726 ILS glide slopes and 221 weather outages or less than one a year, on average, for every three glide slopes. This compares to 583 ILS glide slopes and 547 weather outages in fiscal year 1979, or the equivalent of each glide slope experiencing a weather-related outage about once a year.

[4]The monitor peak detector transforms radio frequency signals from aircraft into audio and direct current signals required by ILS ground equipment, and the output amplifier strengthens the signal coming from the ground equipment, according to an FAA regional office official.

[5]Performance Analysis of: Instrument Landing System Localizer, Glide Slope, Marker Beacons, 1985.

[6]The transmitter/modulator unit and the localizer modulator aid in putting the audio signal course information from ILS ground equipment onto the radio frequency signal sent to the aircraft receiver, according to an FAA regional office official.

According to an FAA official in the current Landings System Program, both monitors are physically located with the newer glide slopes. As of March 1987, this full integral monitoring had been accomplished for about 520 glide slopes. He added that FAA plans to purchase the integral monitoring components for certain of its older solid-state glide slopes and the resulting full integral monitoring will further reduce glide-slope weather-related outages.

ILS Radio Channel Congestion Is Being Managed

The number of radio channels or frequencies for communication between aircraft and ground-based precision landing systems affects the number of systems that can be installed, and, therefore, the volume of air traffic that can be accommodated. Two factors used to determine the number of available channels are the frequency range allocated for ILS usage and the minimum geographic separation between ILSs using the same frequency in which FAA, according to an FAA official, guarantees that ILS signals will be accurate. When MLS was justified, ILS was limited to 20 channels in the radio frequency range and the minimum geographic separation between ILSs assigned the same channel was 200 nautical miles.[7]

FAA has taken a number of actions over the years to reduce ILS channel congestion. It has (1) assigned the same frequency to ILSs at opposite ends of a runway, freeing up frequencies which would otherwise be assigned to runway ends, (2) halved the geographic separation requirements for ILSs using the same radio frequency while still guaranteeing that ILS signals will be accurate, and (3) instituted a policy referred to as "channel splitting" that almost doubles the number of available ILS channels. According to an FAA Spectrum Engineering Division official, whose division is responsible for assigning ILS radio channel frequencies, there are no cases where FAA has been unable to site an ILS because of channel congestion. In addition, channel congestion in FAA's Eastern Region should not be a problem for at least the next 15 to 20 years, according to an FAA Eastern Region official responsible for frequency management.

Assigning the Same Frequency to ILSs at Opposite Ends of a Runway

Beginning in the late 1960s a procedure to assign the same frequency rather than different frequencies to ILSs at opposite ends of a runway was standardized by FAA. This "back-to-back" frequency concept frees

[7] The ILS radio frequency range starts at 108.1 MHz and includes all frequencies to 111.9 MHz (this includes 108.1, 108.3, 108.5, etc.) for a total of 20 channels.

frequencies. As a result, more ILSs can be installed at a given airport or within a given geographical area, thereby permitting more precision landings. As of April 1988, according to an official of FAA's Spectrum Engineering Division, FAA had 77 ILSs using the back-to-back frequency concept at such airports as Los Angeles International, John F. Kennedy International, La Guardia, and Newark International where channel congestion was severe.

Table 2.1 shows that at 14 major airports, 80 of the 100 (80 percent) runway ends qualifying for an MLS already have an ILS. In addition, the table shows that an ILS could be installed at 15 of the remaining 20 runway ends at these airports using the back-to-back frequency concept.

Table 2.1.: Schedule Showing That ILS Frequencies Exist or Are Available for Most Runway Ends Qualifying for MLS at 14 Major Airports

	Number of Runway Ends			
Airport	Qualified for MLS	With ILS	Without ILS	Without ILS but withILS on opposite runway end
Chicago O'Hare International	12	11	1	1
Detroit Metropolitan-Wayne County	7	5	2	1
Los Angeles International	8	8	•	•
San Francisco International	6	3	3	3
Dallas-Ft. Worth International	10	8	2	2
Miami International	6	5	1	1
Wm. B. Hartsfield-Atlanta International	8	8	•	•
La Guardia	4	3	1	1
John F Kennedy International	8	7	1	1
Newark International[a]	6	3	3	1
Stapleton International (Denver)	8	5	3	1
General Edward L. Logan International (Boston)	5	5	•	•
Minneapolis-St. Paul	6	5	1	1
Lambert-St. Louis International	6	4	2	2
	100	**80**	**20**	**15**

[a]One runway has no ILS at either end so theoretically ILSs installed on both ends of the runway could share the same frequency

Source FAA's June 29, 1987, listing of runways that qualify for MLSs

Reducing Geographic Separation Requirements

Another method used by FAA to address the issue of channel congestion has been to increase the number of ILSs that can be installed within a given geographical area by reducing the minimum geographic separation between ILSs using the same frequency. According to an FAA Spectrum Engineering Division official, FAA reduced the area around airports in which FAA guarantees that ILS signals will be accurate from 25 to 18 nautical miles and from 6,250 to 4,500 feet in altitude. These range and altitude reductions resulted in lowering the minimum geographic separation of ILS systems operating on the same frequency from about 200 to about 100 nautical miles, thus increasing the number of ILSs that can be installed.

As illustrated in figure 2.1, a 200-mile geographic separation requirement causes considerable overlap of the same frequency used at different airports. On the other hand, a reduced geographic separation requirement of 100 miles, as shown in figure 2.2, eliminates such overlap. The reduced separation requirement thus allows more airports to use the same frequency without neighboring interference, thereby allowing installation of more ILSs.

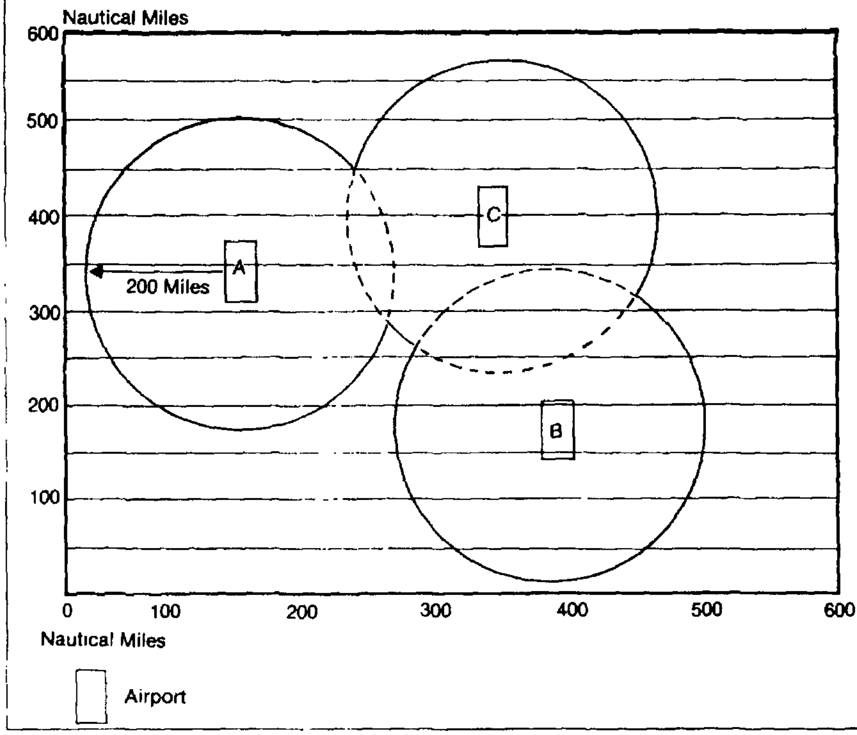
In figure 2.1, ILSs at airports A and B, located more than 400 nautical miles apart, could use the same radio frequencies under the Air Traffic Service's old range and altitude requirements. ILSs at airport C, however, could not use these same frequencies because of the overlap in the minimum 200-mile geographic separation areas with the other two airports. By reducing the minimum geographic separation requirement to about 100 miles, as depicted in figure 2.2, ILSs at all three airports can use the same radio frequencies.

Channel Splitting

A third method FAA uses to address channel congestion is to split channels.[8] Using this technique, the number of available channels can be increased from 20 to between 30 and 35 according to an FAA Spectrum Engineering Division official. FAA issued a policy notice in 1973 stating its intention to use split channeling, when needed, to satisfy future ILS requirements. In 1970 FAA had advised the aviation community that it was necessary to implement split channels to accommodate additional ILSs at certain locations. FAA had further apprised them that aircraft not equipped for the new channel arrangement may not operate safely at certain runways and advised them to consider this when purchasing or replacing their on-board radio equipment.

[8]Channel splitting means that within the ILS radio frequency (108.1 MHz to 111.9 MHz), channels are assigned using 50 kHz instead of 100 kHz frequency. Thus, the channels would include 108.15, 108.35, 108.55, etc., in addition to the 108.1, 108.3, 108.5, etc., channels already in use.

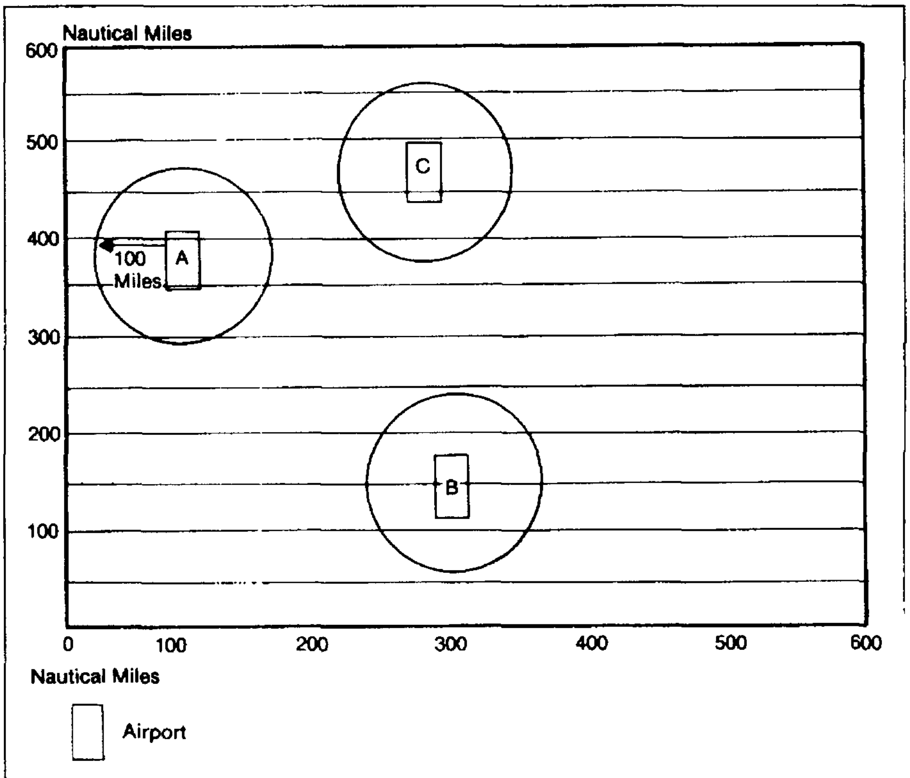
Figure 2.1: Effect of 200-Mile Geographic Separation Requirement on Number of Available ILS Channels



FAA has not found it necessary to broadly implement channel splitting to provide frequencies for new ILSs since it issued its channel splitting policy in 1973. As of April 1988, according to an FAA Spectrum Engineering Division official, only 11 split channels had been assigned and 12 additional split channels are planned, while over 150 ILSs have been installed in the last 11 years.

Much of the aviation community has equipped its aircraft with the necessary avionics equipment to use the new ILS channel arrangement. Presently, all commercial aircraft are equipped with the necessary on-board avionics. Moreover, FAA's most recent General Aviation Activity and Avionics Survey, dated December 1987, shows that an estimated 55 percent of general aviation aircraft in the United States and its territories have the required avionics. In addition, all new equipment being manufactured can accommodate channel splitting, according to an FAA Spectrum Engineering Division official.

Figure 2.2: Effect of 100-Mile Geographic Separation Requirement on Number of Available ILS Channels



ILS Siting Problems Have Been Reduced

Several problems in siting ILSs existed about the time MLS was justified. These problems included (1) the ILS' dependency on level terrain to provide good signals and (2) ILS' susceptibility to interference from reflecting objects in the vicinity of airport runways.

Since the time MLS was justified, FAA has (1) developed a new type of glide slope known as an "end-fire" glide slope and (2) used computer math modeling to solve siting problems. The end-fire glide slope in some instances reduces siting costs, makes possible glide-slope sitings previously not possible, and eliminates certain restrictions associated with the conventional ILS glide slope. Computer math modeling is used to site ILS components and structures, such as airport hangars, to reduce siting costs and/or to minimize interference from reflecting objects.

FAA has not identified on an overall basis those runways where a precision landing system is justified but an ILS cannot be sited, according to officials in FAA's Navigation and Landing Division and Office of Program and Regulations Management responsible for installing, maintaining, and siting ILSs. Moreover, FAA has no listing of such locations. One official estimated, however, that there could be up to 10 locations where an ILS could not be sited.

End-Fire Glide Slopes

The conventional ILS "image" glide slope requires a large amount of level ground in front of it to reflect its signal. The reflected signal combined with a signal from the glide slope's antenna forms the pattern of the glide path seen by the aircraft. However, for certain locations, siting a conventional glide slope (1) requires extensive leveling of terrain, (2) restricts its use because of terrain or objects such as aircraft taxiing to or from the terminal, or (3) is not possible, such as on a mountain top.

Recognizing ILS siting limitations, FAA, in 1972, contracted for the development of an end-fire glide slope. This glide slope does not require level ground in front of it because it uses two main antennas to send an aircraft signal denoting the glide path rather than using one antenna and the ground. FAA purchased 12 end-fire glide slopes. As of January 31, 1988, eight were operational, construction had begun for three more, and the remaining glide slope was being maintained as a spare, according to an FAA official.

The first end-fire glide slope was commissioned at Rock Springs, Wyoming, in November 1979 and, according to an FAA official in the Navigation and Landing Division's Current Landing System Program, the eighth in October 1987 in Charleston, West Virginia. He added that all eight of the installed end-fire glide slopes are operating well and provide Category I landing minimums (requiring greater visibility to land than a Category II system). He also stated that FAA is purchasing two Category II end-fire glide slopes and intends to locate one at Buffalo, New York, and the second at a location to be decided later. This official and officials of four FAA regional offices advised us that there are additional locations where an end-fire glide slope (1) would be installed if an ILS is installed, or (2) could replace a conventional glide slope if the ILS is retained.

End-fire glide slope equipment costs more than conventional glide slope equipment. However, an end-fire glide slope may be more cost effective in some situations because of high site preparation costs, depending on how much terrain needs to be leveled or filled in to site the conventional glide slope.

Computer Math Models

ILSs are also susceptible to signal interference caused by reflecting objects near a runway, including aircraft, structures, and mountains. To address this problem, FAA uses computer math modeling to simulate locating ILSs and to determine the effect existing and proposed objects could have on their operation.[9] FAA uses this modeling technique to (1) determine the most cost-effective way to site ILS components so that they provide required landing minimums while their signals avoid reflecting objects, and (2) site structures near runways so that they do not interfere with ILS signals.

The computer math modeling technique, according to an Ohio University professor of electrical engineering, was developed under an FAA contract with Ohio University in the mid-1960s. However, it was not until at least 1977 that computer math modeling became generally accepted as an aid in solving ILS siting problems. In 1978, FAA's Technical Center began performing ILS computer math modeling, and in November 1979, the Air Force, based on Ohio University math modeling, concluded in a study report of three of their ILS sites that "computer modeling is a very cost effective tool when used at identified problem sites." The Air Force report concluded that for the three sites, computer modeling of glide slopes had identified over $1 million in terrain cost reductions compared to what would have been required by using FAA's siting criteria.

According to the FAA Technical Center's technical program manager, as of February 1987, the Technical Center had conducted 39 ILS computer math modeling studies costing about $10,000 each. In addition, from at least 1978 through 1987, FAA contracted with Ohio University for computer math modeling studies, according to an FAA Navigation and Landing Division official. The Technical Center and Ohio University studies concerned siting ILS components so they function correctly and/or their signals avoid reflecting objects and siting structures in order not to interfere with ILS signals. Examples of these studies include determining where to (1) site a localizer at Hartford, Connecticut, to avoid interference from a dike surrounding the airport, (2) site a glide slope at Killeen

[9]The purpose of the ILS computer math model is to determine what kind of ILS performance to expect under various conditions. The computer is given various data, such as terrain characteristics or a building's height and location. By simulating various types of ILS ground systems, a person can then determine the most cost-effective system to use and where to site it, or where a structure should be located so as not to interfere with an ILS signal.

Municipal Airport, Killeen, Texas, and solve possible uneven terrain problems, and (3) site a glide slope at Butte, Montana, to correct difficulties in maintaining signal quality. As of February 1988, according to an FAA official, FAA is only using its Technical Center for ILS computer math modeling, because the Center is capable of performing the necessary studies and funding is not available for the Ohio University work.

FM Interference No Longer Appears to Be a Problem

FM radio stations signals have, on occasion, interfered with ILS signals. FAA has successfully addressed this problem. To this end, FAA entered into an agreement with the Federal Communications Commission on June 17, 1981. The agreement describes (1) what levels of potential interference are acceptable, (2) what restrictions can be placed on an FM station applicant's construction permit, and (3) what solutions are available when a station's signal frequency exceeds a certain level.

An FAA official advised us that FAA has been successful in resolving all FM radio interference problems. For instance, flight inspection reports showed course deviations and music interference occurring 10 nautical miles from a localizer at National Airport in Washington, D.C. FAA determined that the problem occurred because FAA was using a lower altitude than necessary; the problem was solved by raising the altitude at which the localizer and aircraft begin interacting and changing the localizer-type directional aids.

In another instance, an FM radio station that is located 8 miles from an ILS localizer in North Carolina was interfering with the localizer's signal. According to an FAA Southern Region ILS engineer, the problem was traced to a defective part that was causing the station's operating frequency to be outside the range permitted by the Federal Communications Commission. Therefore, the FM station was operating on a frequency close to the localizer's frequency, causing the interference. Once the defective part was fixed, the interference ceased.

ILSs Now Permit More Aircraft to Land in Lower Weather Minimums

Another concern about ILSs was the need to operate during poor weather conditions. As the minimum visibility required to land decreases from Category I to Category III, the time an airport can remain open during poor weather increases. When MLS was justified, precision landing system runways required either Category I or Category II visibility to land.

Over the years, however, the situation has changed in three major ways: (1) new Category II and Category III ILSs have been installed, (2) Category II ILSs have been modified so that aircraft with certain avionics can land during Category III weather minimums, and (3) FAA has approved more types of aircraft of more air carriers to land in Category III weather minimums. As a result, more aircraft using ILS can land at more airports in poorer weather conditions.

As of May 1987, 11 runways were Category III as a result of either installing new Category III ILSs or by upgrading existing ILSs to Category III. In addition, 57 of FAA's 773 ILSs were Category IIs, and according to an FAA official, as of February 10, 1988, another Category II ILS was being flight tested at Raleigh, North Carolina.

According to a December 1977 advisory circular, FAA can also authorize specifically approved types of aircraft equipped with certain equipment to land in Category III visibility on certain runways equipped with Category II ILSs. Before this, only aircraft with Category III avionics could land on runways having Category III ILSs during Category III weather minimums. According to an FAA Office of Flight Standards official, using ground-based Category II ILSs for landings in Category III minimums was made possible by modifying the ILSs to meet Category III requirements. FAA approval for using Category II ILSs for Category III landings is done on a runway-by-runway basis. As of November 24, 1987, there were 27 runways at 26 U.S. airports that had a Category II ILS approved for Category III operations.

Over the years the number of carriers and types of aircraft approved to land in Category III weather minimums has increased substantially. According to an FAA Office of Flight Standards official, each type of aircraft the air carriers want to use for Category III landings must be approved by FAA. This approval is documented in the carriers' operational specifications, which state not only each type of aircraft, but also those specific runways which can be used for Category III landings. Between 1980 and 1987 the number of carriers with one or more type of aircraft approved for Category III landings increased from 3 to 11 and the types of aircraft approved for Category III landings increased from 2 to 9.

Air Traffic Growth Less Than Forecast

The justification for replacing ILS with MLS was based, in part, on FAA's and DOT's Air Traffic Control Advisory Committee's forecasts of air traffic growth through 1995. This factor, when combined with ILS limitations, could, on the basis of the Committee's report approved by FAA at the time the MLS requirement was established, make ILS incapable of satisfying all future precision landing system requirements. However, according to an FAA official, FAA has not determined the volume of air traffic and resulting precision landings that would preclude ILS from meeting future demands.

FAA forecast a three-fold increase in itinerant instrument flight rule flights, which might use precision guidance to land, between 1968 and 1980, and in coordination with FAA, DOT's Air Traffic Control Advisory Committee forecast an eight-fold increase by 1995.[10] However, the actual number of these flights in 1980 was about half that forecast, and FAA's February 1988 forecast of 1995 air traffic is about a third the number of flights forecast when MLS was first justified.

In 1968, DOT's Air Traffic Control Advisory Committee was tasked with defining the requirements of an air traffic control system adequate for the 1980s and beyond. Requirements were defined using estimates of demand for air transportation for 1980 and 1995.

The Committee's December 1969 report justified replacing ILS with MLS, in part on the basis of forecast air traffic growth, which includes the number of flights based on landings, operating under instrument flight rules. Instrument flight rule flights include most of the flights that require the use of a precision guidance landing system, according to an FAA Office of Flight Standards official.

The report forecast that the number of itinerant instrument flight rule flights would increase from 7 million in 1968 to 20.5 million in 1980, and further increase to 53.9 million by 1995. The actual number of itinerant instrument flight rule flights for fiscal year 1980 was 11.7 million and for fiscal year 1986 was 13.2 million. The number of such flights forecast for 1995 by FAA's Office of Aviation Policy and Plans in its February 1988 publication "FAA Aviation Forecasts Fiscal Years 1988-1999" was 17.7 million.

[10] Itinerant means flights from one airport to another except for military which may be made to the same airport.

An official responsible for air traffic forecasting from FAA's Office of Aviation Policy and Plans said that the methodology and data used in forecasting instrument flight rule flights now are different from, substantially improved over, and more sophisticated than those used in 1969, and that the new method of forecasting using econometric models did not begin until the early to mid-1970s. This official advised us that (1) increased aircraft costs, (2) the introduction of higher passenger capacity aircraft, and (3) increases in the cost of general aviation aircraft fuel have resulted in a lower number of actual and projected flights than forecast in 1969.

We have not validated FAA's current method of forecasting. In this regard we note that in a March 4, 1988, letter to the FAA Administrator, the Air Transport Association of America's Executive Vice President for Administration and Industry Programs stated that FAA has understated commercial aviation growth for 8 out of the 10 years (1978-1987) since deregulation. However, in the context of the assumptions made in 1969, which were for 11 and 26 years into the future, it is clear that the amount of air traffic growth that would occur in terms of the number of flights using instrument flight rules was substantially overstated.

FAA Has Not Reassessed Improvements to ILS and Current Air Traffic Forecasts

Despite the improvements made to ILS and the less than expected air traffic growth, FAA still plans to replace ILSs with MLSs. FAA plans to do this even though it has not reassessed the requirement to replace ILS with MLS recognizing (1) ILS improvements and (2) current and expected air traffic growth.

FAA Intends to Replace ILSs

FAA's precision landing system implementation policy has been to install ILSs where they will benefit the most users at the lowest cost, consistent with overall aviation safety and operational efficiency. By 1982, FAA had revised this strategy to require that all ILSs be replaced by MLSs and that all future precision landing system requirements be met by MLS, except for those few ILS installations whose completion is deemed economically unsound to stop.

At the urging of the aviation community and the Congress, in September 1984, FAA proposed and DOT subsequently approved a revised MLS implementation policy to permit installing a total of 18 new ILSs at airports that (1) qualified for a precision landing system but did not then have one or (2) had an immediate critical aeronautical need for a precision landing system and could economically justify its installation. In May 1987, FAA again revised its MLS implementation policy to permit installing ILSs, on a limited basis, (1) at large and medium hub airports and their associated reliever airports or for documented critical safety requirements and (2) to solve certain capacity problems.[11] At that time, FAA reemphasized its policy that MLS will achieve its effectiveness during the 1990s and will be the primary precision landing system in use well beyond the year 2000.

According to FAA's MLS implementation plan, an MLS can be located alongside an existing ILS (called collocation) for a minimum of 2 years. In addition, no ILS will be removed until all of the airports that connect to the hub (called network airports or spokes) have an MLS and two-thirds of the aircraft with precision landing equipment that routinely use the MLS/ILS equipped runways have MLS avionics. In all cases, however, the ILS will be removed when it has been collocated with a MLS for 10 years.

As a result of the revisions to FAA's MLS implementation policy the Congress has made funds available for up to 32 new ILSs from fiscal years 1987 and 1988, and FAA has requested $10 million for additional ILSs in fiscal year 1989. These ILSs, however, are viewed by FAA as only an interim solution to certain problems such as capacity until sufficient MLSs are deployed.

FAA Has Not Identified Where ILSs Cannot Satisfy Precision Landing System Needs

FAA has ongoing efforts to make better use of its existing ILSs, including (1) increasing their reliability through integral monitoring thus reducing weather-related outages; (2) using computer math modeling studies to aid in reducing or avoiding ILS signal interference; and (3) identifying additional ILS Category II runways which may be used for landings in Category III visibility, according to an FAA Office of Flight Standards official. However, FAA has not identified on an overall basis those runways where a precision landing system is justified but an ILS cannot be sited. This would require identifying where additional ILSs can be installed by (1) assigning the same radio frequency at opposite ends of a runway, (2) utilizing the reduced geographic separation requirements, (3) increasing the number of available channels by channel splitting, (4)

[11] FAA segregates cities and metropolitan areas into four general types—large hub, medium hub, small hub, and nonhub—depending on the amount of passenger traffic.

using end-fire glide slopes, and (5) increasing the use of computer math modeling.

Moreover, according to an FAA Office of Program and Regulations Management official, FAA has not identified the volume of flights or the related number of precision landings that would preclude ILS from meeting future air traffic demands on an airport-specific basis. In addition, according to a 1984 report by the Office of Technology Assessment,[12] other factors, such as the number and layout of runways, the location of an airport in relation to other airports, air traffic control rules and procedures, and other airport equipment, may also limit airport capacity.

Conclusions and Recommendation to the Secretary of Transportation

We believe that FAA must collectively assess the improvements made to ILS since MLS was justified and examine and analyze the less than expected air traffic growth, before it can adequately justify the need for MLS. Therefore, we recommend that the Secretary of Transportation require the Administrator of FAA to reassess the requirement to replace ILS with MLS recognizing improvements to ILS and current and expected air traffic growth. The reassessment should consider (1) improved ILS reliability, (2) increases in the number of available ILS channels, (3) reduced ILS siting problems, and (4) the ability of aircraft to land using ILS in lower ceiling and visibility minimums than previously possible.

[12] Airport System Development, Washington, D.C.: U.S. Congress, Office of Technology Assessment, OTA-STI-231, Aug. 1984.

FAA Has Not Adequately Demonstrated MLS' Potential Operational and Economic Benefits

While ILS has been much improved, it still has certain limitations, including locations at which it cannot be sited and certain reduced visibility conditions under which aircraft are not permitted to land. MLS offers potential operational and economic benefits if aircraft are permitted to land at these locations or under these weather conditions using precision landing equipment. MLS' curved and segmented approach capability and its ability to provide various descent angles also may increase airport capacity and reduce flight delays. However, FAA has not adequately demonstrated these benefits, nor has it addressed the safety and reliability questions that accompany using MLS in challenging operational environments. As a result, valid comparisons cannot be made between ILS, which has proven itself operationally for over 40 years, and MLS, with its number of unknowns.

Testing a system in an operational environment before committing to production has been long recognized by OMB, GAO, and others as an integral and necessary part of the procurement process. FAA recognized early the importance of demonstrating MLS' potential benefits in challenging operational environments. But, faced with escalating program costs and schedule delays, FAA, after only limited demonstrations involving units not built to FAA specifications, entered into an agreement for MLS production in 1984. According to a FAA Office of Program and Management official, FAA will begin taking delivery of the first production MLSs for site installation in April 1988. As a result, FAA could install MLSs and proceed with a second MLS procurement without having adequately demonstrated that MLS' potential benefits can be achieved.

The Consequences of Inadequate Testing Are Well Documented

OMB, GAO, and others have long recognized how important operational testing is for making decisions on whether to commit to production. The negative consequences of going into production without adequately testing a system are well documented. These consequences include subsequent system performance problems such as a system not performing as well as the system it was to replace.

Testing a major system's performance in its expected operational environment before committing to production is an important part of the procurement process established by both OMB Circular A-109 and DOT's implementing order. Production decisions should normally be based on the systems's actual performance in the operational tests.

FAA affirmed the importance of operational testing in its response to a 1978 GAO report on MLS.[1] FAA agreed with our recommendation that MLS needed to be tested in an operational environment and MLS' benefits validated. In its July 1981 MLS Transition Plan, FAA again affirmed its position on the need for operational testing. According to the plan,

> ". . . the National Plan for Development of MLS has, since 1971, specifically provided for an operational evaluation of MLS as a prelude to conducting a full-scale implementation program."

Subsequently, DOT agreed with our recommendation that major systems projects not yet in the production phase be subjected to operational testing as recommended by OMB Circular A-109 and that the resulting data be made available for DOT's production decisions.[2] DOT, in replying to the report recommendation, said that they committed to operational test and evaluation plans where practicable for all major systems and that an independent high-level review group within DOT, the Transportation System Acquisition Review Council, reviews all major system acquisitions to assure that the intent of the A-109 process and our recommendation are followed.

The consequences of not adequately testing a system before making a production decision are well documented. For example, we have found that FAA's use of a fast-track acquisition strategy involving overlapping development and production phases (a practice known as "concurrency"), which did not include adequately demonstrating many NAS plan systems' performance before committing to production contracts, has contributed to schedule delays for many of the plan's major systems; these delays range from 1 to 8 years.[3] A 1984 FAA consultant's study of four major FAA system acquisitions also found that failure to adequately test systems in realistic operational settings before procurement was a major cause of subsequent performance problems.[4] (A more complete

[1] Status of the Federal Aviation Administration's Microwave Landing System (PSAD-78-149; B-164497(1), Oct. 19, 1978)

[2] See Aviation Acquisition: Improved Process Needs to be Followed (GAO/RCED-87-8, Mar 26, 1987)

[3] See Aviation Acquisition Improved Process Needs to be Followed (GAO/RCED-87-8, Mar. 26, 1987), FAA Appropriation Issues (GAO/T-RCED-87-20, Apr. 21, 1987), and Effects of Delays in FAA's NAS Plan (GAO/T-RCED-87-23, May 8, 1987).

[4] MITRE Working Paper: Examination of Testing Activities for Selected FAA Programs, The MITRE Corporation, Aug 1984

discussion of the importance of operationally testing systems prior to production is contained in app. IV.)

The negative consequences of inadequate operational testing are not limited to FAA. Despite warnings from two Blue Ribbon Defense Panels that major systems should not go into high-rate production without benefit of operational test results,[5] most DOD systems still experience a high degree of concurrency between development and production, contributing to problems.[6] For instance, the Air Force started production of a radar warning receiver without benefit of test results. Later tests showed that the receiver did not perform as well as the one it was to replace; the new receivers must be redesigned.

Testing MLS in Challenging Operational Environments Is Important

While the requirement to test a system in its operational environment before committing to production, and the potential consequences of non-compliance are well documented, the question of how much testing should be done is much more subjective and must be developed individually for each system. MLS is intended to replace ILS, which has proven itself operationally for over 40 years. However, MLS' potential operational and economic benefits are contingent on not only its inherent characteristics, but also the success with which it is integrated into the highly complex air traffic control environment in which it must function.

For example, MLS' curved and segmented approaches will require site-specific revisions to standard instrument approach procedures which must be integrated with the traffic control environment. A key factor in integrating MLS into the air traffic control environment is to ensure that all issues related to safety are recognized and satisfactorily addressed. It is important, therefore, that an MLS testing program include not only integrating MLS into the air traffic control environment, but also the safety aspects of landings and the aborting of landings. Other important factors that must be addressed as part of the testing program are (1)

[5] Report to the President and the Secretary of Defense on the Department of Defense: Staff Report on Operational Test and Evaluation, Blue Ribbon Defense Panel, Appendix F, July 1970 and A Formula for Action: A Report to the President on Defense Acquisition, President's Blue Ribbon Commission on Defense Management, Apr 1986

[6] See Operational Test and Evaluation Can Contribute More to Decisionmaking (GAO/NSIAD-87-57, Dec. 23, 1986) and Production of Some Major Weapon Systems Begun With Only Limited OT&E Results (GAO/NSIAD-85-68, Jun. 19, 1985).

airline pilot acceptance of the banking required for curved and segmented approaches and aborted landings resulting from buildings,[7] and other obstacles in the approach and missed approach paths, (2) the impact of required operational procedures on pilot and air traffic controller work load, and (3) the displacement of aircraft noise to other geographic areas.

FAA Recognized the Need to Operationally Test MLS

FAA planned to address questions and uncertainties regarding MLS' performance characteristics and cost-benefit tradeoffs by demonstrating its performance and operational and economic benefits in challenging environments. FAA's two-phased approach to validate and test MLS, called the Service Test and Evaluation Program (STEP), began in 1979. The first phase was to conduct tests using an MLS prototype while the second phase was to use production-type MLSs to obtain "real world" operational experience.

For the first phase, FAA planned to use up to four existing research and development prototype MLSS. FAA expected the first phase to address, but not satisfy, the program's objectives because the prototype MLSS (1) were considered by FAA to be unsuitable for proper reliability demonstrations, especially in weather extremes for which the hardware was not designed; (2) did not have the wide-proportional guidance needed to conduct curved and segmented approaches; and (3) could not be used for required additional development and evaluation of remote system monitoring.

The second phase of the program was to use MLSs built to FAA production specifications, which would make them better suited than the MLS prototypes used in the first phase to demonstrate MLS' performance in difficult airport environments. The second phase was to deploy approximately 10 to 20 production MLSS, which would allow for an increase in the number and variety of users and flight operations and a wider range of environmental stress conditions than could be accomplished under phase one. The larger number of second phase systems would also provide a larger data base than the first phase, permitting more accurate conclusions to be reached and instilling greater confidence in MLS in both the program participants and the aviation community at large.

[7]Banking is the lateral slope an aircraft makes on a turn with its inside wing low and its outside wing high so as to prevent slipping sideways

FAA also planned a number of special tests to respond more fully to user questions and concerns. These tests included demonstrating MLS in wide-body aircraft, determining helicopter applications of MLS, evaluating curved and segmented approach operational procedures, and demonstrating MLS' capability to land in Category III visibility conditions. According to FAA,

> "Before MLS can be accepted for airline-wide implementation, and as a means to verify potential benefits, the full capability MLS must be demonstrated to be suitable for use in the larger, as well as smaller airline aircraft."[8]

MLS Tests and Evaluations and Other Demonstrations Not Adequate

FAA did not complete its MLS test and evaluation program as planned. Only the program's first phase was completed; the second phase was never begun. At about the same time as the test and evaluation program was curtailed, FAA decided to enter production of MLS. FAA has since begun conducting several MLS demonstrations. However, these demonstrations do not provide for the full testing of MLS' potential capabilities. Additional MLS demonstrations are now planned by FAA.

MLS Tests and Evaluations Not Completed

Originally estimated to cost $2.5 million and last 2 years, the first phase of the test and evaluation program took 7 years and is estimated to cost $17 million to complete. Start-up problems caused program delays which, in turn, created overall cost growth in areas such as avionics procurement and engineering and test support. As a result, the second phase was never begun and was eliminated from the program in 1981. Additionally, the special tests designed to address user questions and concerns, including demonstrating MLS in wide-body aircraft and evaluating curved and segmented approach operational procedures, were curtailed.

Under the first phase of the test and evaluation program, FAA tested prototype MLSs at (1) three airports with aircraft of two commuter airlines landing only in good weather and using straight-in rather than curved and segmented approaches and (2) a National Aeronautics and Space Administration (NASA) test facility in good weather, using aircraft that had not been certified to FAA's air carrier standards. Prototype MLSs were installed at Washington National Airport, Philadelphia International Airport, and Benedum Airport in Clarksburg, West Virginia. But the MLSs installed at these airports had two limitations. First, they were

[8]Microwave Landing System Service Test and Evaluation Program, February 26, 1979, FAA.

not certified by FAA for precision landings, and all approaches flown were in good weather. Second, the MLSs could be used only for straight-in rather than curved approaches.

Two commuter airlines were enlisted to participate in the operational evaluations using FAA-furnished avionics. However, after limited operational testing, one airline was sold and testing at the Clarksburg airport was terminated. This left one commuter airline landing at Washington National Airport and Philadelphia International Airport to provide the test data. The test demonstrated MLS using straight-in approaches in good weather.

A prototype MLS was also installed at NASA's Wallops Island, Virginia, Flight Center. Curved-approach landings were flown using a specially equipped NASA B-737 aircraft. Although the B-737 aircraft is a part of the civil aviation fleet, the one used by NASA was not equipped and certified to FAA's standard for commercial aircraft. Further, although commercial airline pilots made curved approaches, the flight tests were not conducted in an operational environment or at a commercial airport.

MLS Demonstrations

In addition to its curtailed test and evaluation program, FAA initiated two other MLS demonstrations. These two demonstrations started after FAA entered full MLS production. The first began in August 1985, in Richmond, Virginia, and the second began in May 1987 in Wichita, Kansas. Their goals are to certify individual types of general aviation aircraft with MLS avionics and to demonstrate some MLS capabilities. However, each demonstration is using commercial MLSs not built to FAA specifications, and only straight-in and not curved and segmented approaches.

FAA, in a project headed by its Eastern Regional Director, is developing a plan to demonstrate MLS' capabilities with a limited number of production units that meet FAA's specifications, according to an FAA Eastern Regional Office official. The official added that the plan includes demonstrations using two of the initial 178 MLSs—one at Washington's National Airport and the other at New York's LaGuardia Airport—and MLS avionics-equipped Eastern and Pan American Boeing 727 transports serving their New York to Washington shuttle. An MLS installation is also planned at New York's new Wall Street Heliport. With installation of the MLS, FAA hopes to provide a precision landing approach for the heliport. The official further advised us that no definitive plans have been made as to how comprehensive the demonstrations will be or when they will begin. Further, the MLSs to be used will be Category I; thus, aircraft will not be permitted to land in the lower visibility Category II and Category III weather conditions.

FAA Has Not Adequately Demonstrated MLS' Potential Benefits or Identified Its Limitations

According to an FAA Navigation and Landing Division official, although the test and evaluation program did not fully achieve its original objectives, the results, along with tests of MLSs at airports throughout the world, enabled FAA to proceed into production with confidence. However, FAA's demonstrations to date indicate only that certain operational benefits are technically feasible using MLSs not built to FAA specifications at a limited number of locations and off-the-shelf, commercially-available on-board avionics under controlled air traffic and weather conditions.

Such demonstrations do not show that MLS' potential operational benefits are obtainable, nor do they answer questions concerning the system's safety and reliability. For example, conducting curved approaches in aircraft not certified by FAA in good weather and at only one location is not adequate to demonstrate MLS' curved approach capability. Similarly, using commuter and general aviation aircraft to fly straight-in ILS-like approaches in good weather only is not adequate to demonstrate MLS' potential operational and economic benefits or to answer the safety-related questions associated with either curved and segmented approaches or landings in lower visibility weather conditions than ILS.

Conclusions and Recommendations to the Secretary of Transportation

We do not share FAA's confidence that the tests to date are adequate to proceed with production of additional MLSs. FAA has not adequately demonstrated MLS' potential operational and economic benefits such as those associated with (1) installation at locations where an ILS cannot be sited, (2) landings in lower visibility than can be achieved by using ILS, and (3) curved and segmented approaches. It also has not addressed the safety and reliability questions that will accompany deployment of MLS in challenging operational environments.

To FAA's credit, it originally intended to conduct such testing with a limited number of pre-production MLSs before entering production. Instead, faced with program delays and cost increases, FAA scaled back its testing program and, as a result, neither answered the questions nor resolved the uncertainties regarding MLS' performance characteristics and cost-benefit tradeoffs. The curtailed testing program also failed to demonstrate MLS' operational and economic benefits in challenging airport environments. Until this is done, neither the FAA nor DOT's Transportation Systems Acquisition Review Council will have an adequate basis for justifying how many MLSs are needed and where they should be sited.

Therefore, we recommend that the Secretary of Transportation direct the Administrator of FAA to demonstrate MLS' benefits by testing the system in the challenging airport environments in which it is to be used. This should be done before proceeding with further MLS procurements. The operational tests should involve

- wide-bodied aircraft,
- landing at major hub airports having difficult and complex operating requirements,
- both good and poor weather conditions,
- both curved and segmented approaches, and
- operating under the control of FAA traffic controllers and interfacing with the air traffic control environment.

FAA's MLS Siting Strategy Needs Reassessment

Since 1984, FAA has twice revised its listing of locations scheduled to receive the first MLS procurement on the basis of changing selection criteria. FAA's latest listing was intended to locate MLS, based on potential users willingness to equip their aircraft with MLS avionics. This apparent interest in MLS, which might stem in great measure from FAA's 1982 decision not to install any new ILSs, but instead install MLSs, has been seriously questioned by DOT's Inspector General. In addition, these listings have been prepared by FAA without a thorough assessment of ILS improvements and air traffic growth, or the results of operationally testing MLS in challenging airport environments.

FAA's MLS Implementation Strategy Has Been in Flux Since 1984

FAA's January 1984 MLS location listing identified clusters of airports connected to large and medium hub airports including Boston, New York, Atlanta, Denver, Los Angeles, and Alaskan networks to receive the first MLSs. In September 1985, 26 new locations were added while 10 of the original 172 locations were deleted because they were not cost-beneficial. Another 16 locations were deferred until a later date in favor of higher priority locations. Six more MLSs were changed to different runways or opposite runway ends to improve utilization of airspace, or relieve an environmental impact. In August 1987, the listing was revised again. Another 45 new locations (including one identified as being clearly not cost-beneficial in September 1985) were added while a corresponding number of MLSs at 28 airports (including two added by September 1985) were deferred.

The locations have changed because FAA keeps changing its selection criteria. A key criterion used by FAA for its January 1984 listing was the "network concept." Under this concept MLSs are installed at hub airports and their connecting airports. These form networks based on the capacity/delay relief expected to be achieved by the airports' users.

Subsequent cost-benefit analyses showed that some locations on the January 1984 list were not cost-beneficial and that other higher-priority locations existed. FAA, therefore revised its January 1984 listing and issued a new list by September 1985.

User Support Appears Lacking for FAA's Latest Location Listing

FAA's August 1987 location listing was developed by an MLS Deployment Review Working Group chaired by FAA's Eastern Regional Director and convened by the FAA Administrator early in 1987. The group was tasked with identifying locations where MLS could provide increased operational benefits. These identifications were made on the basis of scheduled carriers' verbal commitments to equip their aircraft with MLS avionics if certain locations were included in the first 178 systems to be installed.

On the basis of conversations with officials from 4 air carriers and 10 regional and commuter airlines, the working group concluded that the airlines were willing to install MLS avionics in 317 aircraft if MLSs were installed at certain airports. However, subsequent discussions conducted by DOT's Inspector General with representatives from 8 of the 14 airlines who supposedly had agreed to equip 263 of the 317 aircraft, indicated that they were willing to equip only 60 aircraft with MLS avionics—less than 25 percent of the number reported by FAA. The Inspector General concluded that the August 1987 location listing does not have the degree of user support FAA thought existed, and, if the listing is not carefully reexamined, MLSs will be installed at airports where they will not be extensively used.

The Inspector General recommended that FAA's August 1987 location listing be reevaluated and that FAA delay the second procurement of 500 MLSs until a revised implementation plan is developed. We agree, but caution that a sound MLS implementation strategy cannot be developed until, as discussed earlier, FAA has (1) assessed the collective impact of improvements made to ILS over the last 19 years on the need for MLS and (2) demonstrated MLS' operational and economic benefits by operationally testing the system in the challenging airport environments in which it is to be used.

Conclusions and Recommendations to the Secretary of Transportation

The methodology used and the validity of the information obtained by FAA in developing its August 1987 MLS siting listing is questionable. It would seem more prudent to base the location listing as well as the number of MLSs needed on written agreements rather than general verbal statements. To do this, FAA would have to compare the results of testing MLS in the challenging airport environments in which it is to be used to the much improved ILS recognizing current and expected air traffic growth. Because this comparison has not been done, we recommend that the Secretary of Transportation direct the Administrator of FAA not to proceed with the planned second MLS procurement unless the assessment of ILS improvements and air traffic growth as well as the operational testing of MLS have been completed.

In the interim, FAA must accept delivery of 178 Category I MLSs. We recommend that FAA use these MLSs

- in the operational tests recommended in chapter 3;
- on some of the 101 international runways discussed in chapter 1, if internationally-scheduled airlines are willing to acquire the necessary on-board avionics;
- at locations that qualify for a precision landing system but where FAA can clearly show that ILS cannot be sited because of terrain or obstacles in the approach or missed approach path, described in chapter 1; and
- at heliports, which were also discussed in chapter 1.

User Views Toward MLS Differ and Questions and Concerns Remain Unanswered

In the early 1970s, the aviation community enthusiastically embraced MLS as the precision landing system of the future. Today, user support is not as widespread as it was in the past, and user questions and concerns about MLS' potential operational and economic benefits remain largely unanswered.

Among the airlines, major air carriers believe the improved ILS is reliable and satisfies most of their precision landing needs. They are not convinced that MLS' potential operational and economic benefits warrant investing billions of dollars to acquire the necessary on-board avionics. As a result, the Air Transport Association of America (ATA), which represents most U.S. airlines, recently took the position that ILS should be the primary and MLS the secondary precision landing system. To accomplish this, ATA has recommended that FAA take the necessary action to modify the United States international MLS agreement by extending the date ILSs are to be eliminated from international runways. Presently, the United States has agreed to install MLSs and eliminate all ILSs on 101 international runways by January 1, 2000.

International carriers, while still supporting MLS as the worldwide replacement for ILS, have similar questions concerning MLS' potential benefits and costs. Regional and commuter airlines support more precision landing systems, either ILS or MLS, on the runways they use.

Commercial pilots support the MLS program but believe that additional testing is needed before the MLS can be used for curved or segmented approaches. In the interim, they are primarily concerned that runways on which they land be equipped with a precision landing system. General aviation pilots have lost interest in the MLS program because of the anticipated high cost to equip aircraft and what appears to them to be little in the way of benefits. As such, they support the installation of more ILSs.

FAA has stressed that the other primary user of MLS—the Department of Defense (DOD)—plans to acquire 405 ground-based units, including 194 in the proposed second buy, and that compatibility between civilian and military systems is critical. We found, however, that the military services plan to maintain compatibility between ILS and MLS by (1) maintaining both ILS and MLS equipment in certain aircraft and (2) developing dual-avionics equipment for other aircraft that will be compatible with both ILS and MLS ground-based systems.

Air Carriers Are Generally Satisfied With ILS and Question MLS' Benefits

Air carriers generally believe that the much improved ILS can meet most of their existing and future precision landing system needs. However, they believe that there are locations where an MLS, but not an ILS, can satisfy their precision landing system needs. They also believe that FAA has not demonstrated that the incremental operational and economic benefits MLS may provide at certain airports are worth installing the avionics necessary to use MLS.

Major Air Carriers Believe That ILS Meets Most of Their Needs

Officials at the 10 major air carriers we surveyed and the ATA, which represents the U.S. airlines that account for 97 percent of the service provided by all U.S. scheduled airlines, believe that the improved ILS is reliable and capable of satisfying most of their precision landing system needs.[1]

According to the air carrier officials we surveyed, ILS will generally satisfy their precision landing system needs over the next 10 to 15 years if more ILSs are installed at locations where precision landing systems are justified. They generally maintained that they are satisfied with the solid-state ILS' reliability and that if few system outages occur, including those caused by snow, they have little effect on their operations. According to them, if there is a snow-related ILS outage which affects air carrier operations, it is usually accompanied by a general airport shutdown.

According to most of the air carrier officials we surveyed, MLS has the potential to satisfy those few precision landing system needs that cannot be fully satisfied by ILS. This includes runways where an MLS, but not an ILS, can be sited.

Air Carriers Not Convinced of MLS' Incremental Benefits

Air carriers are not convinced that MLS' incremental operational and economic benefits justify the investment in on-board avionics, including a sophisticated computer and precision distance measuring equipment needed to perform curved and segmented approaches. One major carrier estimated that the on-board avionics necessary for curved and segmented approaches will cost $375,000 per aircraft, or almost $76 million to equip its entire fleet.

[1]The 10 carriers we surveyed represented about 67 percent of all passengers enplaned in 1985 on U.S. scheduled airlines.

FAA was put on notice early that it would have to provide the user community with factual information about benefits if it hoped to win their support. A July 1977 report by the Radio Technical Commission for Aeronautics said that the user community makes capital investment decisions on the basis of economic considerations of perceived benefits versus cost.[2] Such decisions—including those concerning MLS—require factual data. To this end, the report stated that "... it is essential that FAA conduct further work to validate and quantify benefits" and recommended that FAA establish test and demonstration programs to substantiate some benefit areas, such as delay reductions and capacity increases.

FAA has also recognized the need to provide the user community with factual data on MLS' operational and economic benefits. For example, in a March 1981 hearing before the Subcommittee on the Department of Transportation and Related Agencies Appropriations, House Committee on Appropriations, FAA's Associate Administrator for Aviation Standards said that the transition to MLS will require operational testing and evaluation by FAA to demonstrate its procedures to the people who must operate the system. In August 1981, however, FAA abandoned its plan to demonstrate MLS' performance in difficult operating environments.

According to FAA, the ability of MLS to increase airport capacity and reduce flight delays is contingent, in part, on the system's capability to provide for curved approaches. Yet, as stated in ATA's March 4, 1983, letter to the FAA Administrator, and as reiterated to us in October 1987 by ATA's senior vice president for technical services, FAA has not demonstrated this ability. ATA expressed concern that until this ability is demonstrated, the airlines had little incentive to implement MLS.

MLS benefits need to be demonstrated and validated in operating environments, according to air carrier officials we surveyed. Unless that is done, they questioned the extent to which MLS curved approaches will ever be used at most locations and whether they will provide meaningful benefits compared to ILS. Concerns included (1) whether curved approaches will provide benefits at only a few airports, thus not warranting the cost to install the required equipment on their entire fleets and (2) whether air carrier management will insist on a final straight-in approach distance for MLS similar to that now being used for ILS, thus

[2] Microwave Landing System (MLS) Implementation, Radio Technical Commission for Aeronautics, Volume I, DO-166, July 1977

reducing the benefits to be obtained from MLS' curved approach capability.

In summarizing ATA's position in 1983, the Senior Vice President for Operations and Technical Support said that unless MLS benefits are validated and its full capabilities are interfaced into the air traffic control system, "FAA is simply replacing ILS with another high-technology precision landing aid with no significant improvement in service or productivity." More recently, ATA has advocated testing curved and segmented approaches in wide-body aircraft as well as the performance of a cost-benefit study that takes into account ILS improvements and the results of curved and segmented approach testing, according to an October 1987 statement by ATA's senior vice president for technical services.

In a March 10, 1988, letter to FAA's Administrator, the president of ATA stated ATA's most recent position on precision landing systems. The letter recommended that FAA revise the NAS Plan to retain ILS as the United States' primary precision landing system. ATA also recommended that FAA take the actions necessary to extend the international date for which MLS becomes the standard precision landing system beyond January 1, 1998, so that ILS can be retained as the primary precision landing system. The letter further stated that MLS should be adopted as an internationally standardized secondary system for use at airports or on runways where ILS cannot meet the technical and operational needs of the users. (See app. V for a copy of the letter.)

International Air Carriers Are Also Questioning MLS' Benefits

The International Air Transport Association (IATA) comprises 165 member airlines and claims to represent 75 percent of all scheduled international airlines. It continues to support the international commitment to MLS as the replacement for ILS. The IATA, however, has expressed concerns similar to those raised by ATA.

IATA continues to support ICAO's plan to eliminate all ILSs from international service by January 1, 2000, and to install MLSs on all runways used by internationally-scheduled airlines, according to a January 29, 1988, letter to us from the head of IATA's Technical Department. He continued, however, that IATA's member airlines were concerned about the cost-effectiveness of MLS, including (1) the higher than anticipated cost of the ground-based units, (2) the extent and timing of realizable MLS benefits, and (3) the apparent lack of progress in actively addressing, through research and development programs and other initiatives, the prerequisite measures necessary to eventually realize MLS-related benefits.

According to the IATA official, any circumstances or actions that could jeopardize an ICAO country's ability to fulfill its obligations under the approved ICAO plan should be swiftly referred to ICAO for consideration of the international consequences. He believed that this responsibility was especially critical for members with a large number of international runways, such as the United States, where the effects on air carriers of other member countries could be considerable and costly.

The size of the U.S. MLS program is reflected in the fact that it represents about 80 percent of the MLSs being purchased by the United States, Canada, Australia, and 25 European countries. FAA intends to begin fulfilling the United States' ICAO agreement by installing 21 of the first 178 MLSs on internationally-designated runways. The remaining 80 of 101 MLSs needed to satisfy the ICAO commitment are to be installed following subsequent buys. Of the 101 MLSs, 31 must be Category II MLSs, according to the international agreement. The first 178 MLSs are Category I and may not satisfy the Category II requirement.

FAA has until January 1, 2000, to satisfy its international requirements, and even longer if the international date when MLS becomes the standard precision landing system is extended, as ATA has suggested. In the interim, FAA should perform the tests and evaluations necessary to adequately address IATA's concerns about MLS' cost and benefits.

Regional and Commuter Airlines Continue to Support MLS

The support for MLS within the regional and commuter airlines is based primarily on the fact that it can increase airport capacity at congested airports and provide precision landing capability not provided by ILS. Regional and commuter airlines have been hard hit by FAA's moratorium on installing ILSs. The moratorium, coupled with an over 2-year delay in installing the first MLS, has made few additional precision landing systems available to this segment of the airline industry during the period 1982 to 1987. As a result, over 200 of the 824 airports served by regional and commuter airlines still have no precision landing capability.

The Regional Airline Association (RAA) is interested in obtaining precision landing capability for those runways used by its members that do not presently have a precision landing system.[3] This capability, according to RAA, can be either MLS or ILS; however, RAA believes that some of its precision landing capability needs can only be satisfied by MLS. As a result, through the years RAA has been and continues to be a strong proponent of MLS.

RAA believes that MLS may solve two industry problems. First, there are many smaller commercial airports without a precision landing system. In some cases these airports do not have enough traffic to justify an ILS under FAA's former ILS criteria, while in other cases, ILSs cannot be sited at these airports. Second, many shorter runways at major airports are without precision landing systems. This adds to congestion at major airports during periods of adverse weather conditions because turboprop aircraft have to land on the same runways as the larger jet aircraft. Installing MLS on the shorter runways at major airports together with using MLS' curved approach capability may aid in alleviating delays and congestion, according to RAA.

Commercial and General Aviation Pilots Differ in Their Views of MLS

Commercial and general aviation pilots have different views concerning the use of MLS and ILS. Commercial pilots support the MLS program because they believe there should be a precision landing capability at every runway used by air carriers, and that MLS can accomplish this better than ILS. On the other hand, general aviation pilots believe that any benefits they would receive from MLS do not justify retrofitting their aircraft with MLS receivers.

Commercial Pilots

The Airline Pilots Association (ALPA) supports the MLS program because precision landings are inherently safer than nonprecision ones.[4] ALPA believes that a precision landing capability at every runway used by air carrier aircraft can best be satisfied by MLS. This is because (1) MLS can be used for runways where an ILS cannot be sited and (2) FAA is revising its MLS qualifying criteria to permit MLS for runways that could not previously qualify for precision landings.

However, according to ALPA's deputy director for engineering and air safety, ALPA members will use MLS for only straight-in, ILS-like

[3]RAA represents carriers that provide regularly scheduled passenger and/or cargo service with aircraft seating less than 60 passengers and a cargo payload capacity of 18,000 pounds or less. In 1986 there were 179 regional and commuter airlines serving 824 airports.

[4]ALPA represents 40,000 pilots who fly for 43 commercial airlines.

approaches in no worse than Category I visibility conditions until additional MLS research and testing is done. This research and testing would include such things as testing the integrity and reliability of the MLS software, testing obstacle clearance criteria, and development of cockpit displays. Meanwhile, according to ALPA, if MLSs are not installed then ILSs should be used.

General Aviation Pilots

The Aircraft Owners and Pilots Association (AOPA), which represents about 260,000 general aviation pilots who own over 135,000 aircraft, believes that ILS can satisfy most of its members precision landing needs. In January 1986, AOPA's president, noting improvements in ILS technology, said that MLS may be replacing a system—ILS—that is satisfactory. Further, AOPA believes that, in large part, advancing ILS technology short-circuited many previously identified MLS benefits and there is no reason to spend the estimated $2.1 billion required to retrofit general aviation aircraft with MLS receivers.

As a result, AOPA has urged the Congress to install more ILSs. At FAA's fiscal year 1988 appropriation hearings before the Subcommittee on the Department of Transportation and Related Agencies Appropriations, House Committee on Appropriations, AOPA, noting the moratorium on installing ILSs and the delays in the MLS program, recommended the prompt installation of ILSs at locations that qualify for a precision landing system.

Civilian and Military Compatibility Appears Assured

The other primary user of MLS is DOD, and FAA maintains that, unless ILS are replaced with MLSs, the lack of compatibility between civil and military systems will adversely affect the ability of each to use the other's facilities. DOD, however, appears prepared to solve this problem by equipping its aircraft with receivers that can use both MLS and ILS as it makes the transition from ILS to MLS ground units.

DOD plans to acquire 405 MLSs to satisfy its fixed ground-based requirements. DOD also plans to acquire mobile MLSs to satisfy its tactical operational requirements for a portable system.[5]

[5]Mobile MLSs are systems that can be airlifted to where they are needed and then set up within an hour.

The Air Force plans to equip 2,600 of its transport aircraft with modified commercial MLS equipment while retaining the ILS equipment. Similarly, the Army plans to equip 20 percent of its 9,000 aircraft, including helicopters, with MLS equipment. All Army aircraft, however, that are now equipped with ILS avionics will retain that capability until MLS is generally implemented.

According to the Director of DOT's Research and Special Programs Administration, the Air Force is initiating advanced studies directed toward full-scale production of equipment by 1992 that integrates on-board ILS and MLS avionics. This equipment is to occupy no more space in an aircraft than ILS-only equipment, and the Air Force intends to equip 7,700 high performance aircraft with this integrated ILS/MLS equipment. The Director further stated that commercial outgrowths of this integrated equipment, which would enable commercial airlines to obtain this dual avionics, are expected.

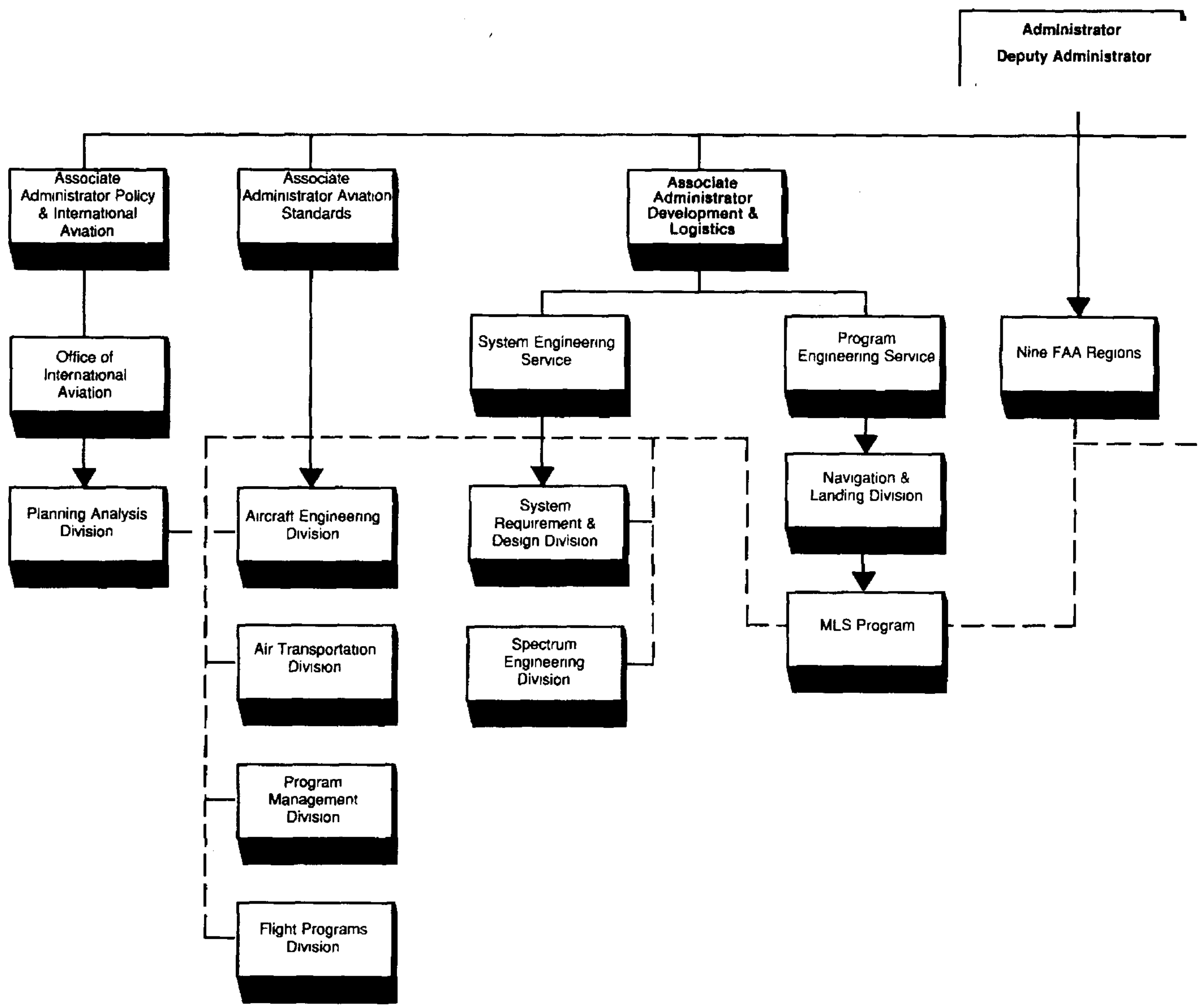
The Navy and Marine Corps plan to equip their aircraft with an avionics system designed to meet their needs from 1988 through 1998. The system will be compatible with the civilian sector, Air Force, and Army, and have both ILS and MLS capability. It will also provide a capability for aircraft carrier landings.

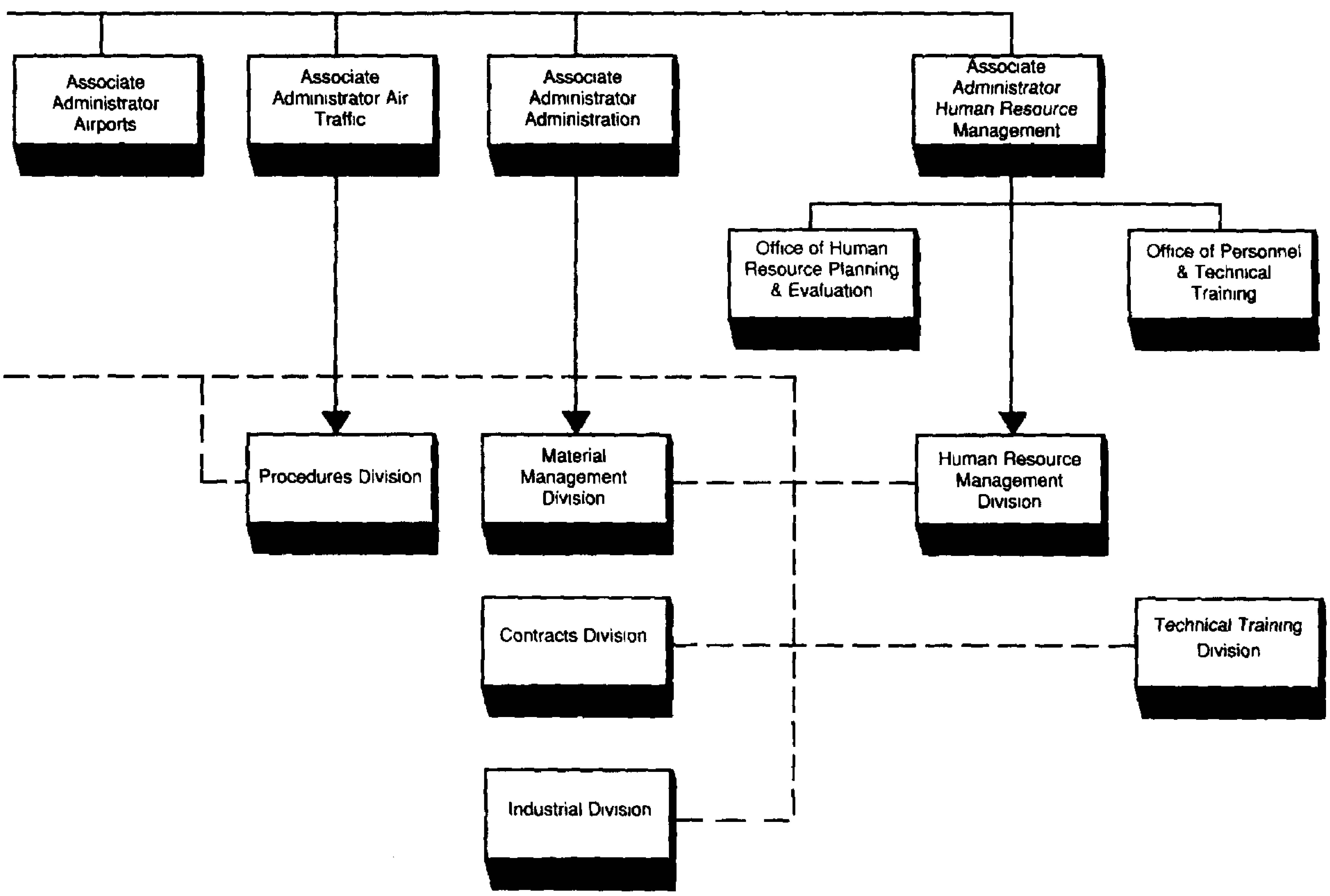
Conclusions and Recommendation to the Secretary of Transportation

Over the years, FAA has not adequately addressed user concerns and questions about MLS. As a result, air carriers and general aviation pilots are no longer convinced that MLS' incremental benefits warrant investing in the necessary on-board avionics. Even the more vocal proponents of MLS, including foreign, regional, and commuter airlines and commercial pilots believe that additional tests and evaluations are needed to answer MLS' many unknowns. Meanwhile, the various military services appear prepared to initially assure compatibility between civil and military precision landing systems in the air rather than on the ground by equipping their aircraft with both ILS and MLS avionics.

FAA will require time to collectively assess the improvements to ILS and analyze the impact of less than expected air traffic growth on the need for MLS, and to adequately demonstrate MLS' potential incremental benefits. Therefore, we recommend that the Secretary of Transportation require the Administrator of FAA to take the action necessary to maintain ILS as the primary landing system nationally and internationally until the assessment, analysis, and demonstrations have been completed.

FAA Organizations Involved in the MLS Program

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GAO Comments to FAA Concerning MLS Cost-Benefit Studies

GAO

United States
General Accounting Office
Washington, D.C. 20548

Resources, Community, and
Economic Development Division

January 29, 1987

Mr. Frank L. Frisbie, Acting
Associate Administrator for
Development and Logistics
Federal Aviation Administration

Dear Mr. Frisbie:

As you know, we are reviewing the Federal Aviation Administration's (FAA's) microwave landing system (MLS) program, which is to provide the aviation community with a new precision landing capability. Recently, FAA requested Martin Marietta--the system engineering and integration contractor for the National Airspace System Plan--to update the cost/benefit study used to justify the federal government's estimated $1.5 billion MLS program. The study, which includes a life-cycle cost analysis, compares the existing instrument landing system (ILS) with the proposed MLS. We understand the target date for the study's completion is April 1987.

On the basis of our work to date, we agree with FAA that an update is appropriate. Among other factors, technological advances, improved ILS equipment efficiency, and cost escalation affect the validity of the assumptions and calculations made in the original 1976 study and a limited 1983 update. We also recognize that the April 1987 completion date is necessary because FAA has requested fiscal year 1988 funding for the MLS program. This should make the study results available prior to the fiscal year 1988 appropriation hearings.

Recognizing the tight time frames facing FAA, we have already briefed your staff on our observations about both the original 1976 MLS cost/benefit study and the limited 1983 update. We appreciated the opportunity to provide this input. Your staff said our observations would be considered in conducting the new study and, as agreed with them, these observations are summarized in this letter. We must caution, however, that our work on the MLS program is continuing and may identify additional issues that are relevant to the cost/benefit study.

PASSENGER TIME SAVINGS

The 1983 update revised the cost of MLS compared to ILS, but did not adjust the incremental benefits attributable to MLS. Adjusting these benefits is important since the 1976 study appears to have overstated passenger time savings benefits in two ways.

First, a full hourly wage rate was used rather than a fraction of the wage rate to value passenger time savings. For nonbusiness travelers, empirical studies[1] have shown that their time should be valued at less than the full hourly wage rate. For business travelers, a Congressional Budget Office study[2] points out that the full wage rate will overstate savings to the extent business travel time is spent productively.

Second, a value was placed on very small increments of passenger time saved--12 seconds--by using MLS instead of ILS. To be valuable, time increments need to be significant enough for passengers to perceive that time savings have occurred and to embark on a meaningful alternative activity. In this regard, we note that the Office of Management and Budget's position is that time savings benefits should be based on time increments of at least 10 to 15 minutes. While there may well be circumstances where time savings of less than 10 minutes can appropriately be valued, we were not able to determine the basis for placing a value on increments of 12 seconds.

Another important issue concerning the value of passenger time savings lies in the measure of income used to determine the wage rate. If the study update follows FAA's current wage rate methodology, a wage rate that includes wage and non-wage income of the traveler and the traveler's family would be used. This would overstate the traveler's wage income and the corresponding value placed on MLS benefits.

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[1]The results of many empirical studies are summarized in the following survey articles:

David A. Hensher, Review of Studies Leading to Existing Values of Travel Time, Transportation Research Board's Transportation Research Record, Number 587, 1975.

Nail Cengiz Yucel, A Survey of the Theories and Empirical and Investigations of the Value of Travel Time Savings, International Bank for Reconstruction and Development's Bank Staff Working Paper 199, 1975.

Jay R. Cherlow, "Measuring Values of Travel Time Savings," Journal of Consumer Research, Vol. 7 (March 1981), pp. 360-371.

[2]Improving the Air Traffic Control System: An Assessment of the National Airspace System Plan, August 1983.

2

Since estimated passenger time savings benefits in the 1976 study are $295 million or about 44 percent of the estimated $671 million in total incremental benefits attributable to MLS, the benefit/cost ratio will be highly sensitive to any changes in the wage rate assumptions. Also, in commenting on our report entitled "AIRPORT RADAR ACQUISITION: FAA's Procurement of Airport Surface Detection Equipment" (December 1986), the Department of Transportation noted that FAA plans to conduct a study on ways to improve cost/benefit methodologies for the measurement and valuation of passenger time savings. Since passenger time savings are relevant to a wide range of NAS projects, we hope you find the foregoing observations useful in conducting this study as well as the MLS cost/benefit analysis.

OTHER BENEFIT ASSUMPTIONS

Our work also raises questions about whether certain other assumptions in the original analysis can be supported in a 1987 environment and beyond. Together, these assumptions affect $336 million in assumed benefits or about 50 percent of the total incremental benefits attributable to MLS.

First, the assumptions about how often and where the curved approach will be used were based on a questionnaire given to airport operators but without data from other potential MLS users. Data from key user groups such as pilots and aircraft operators would seem relevant to the curved approach usage issue.

Second, with the conversion of ILS from tube-type to solid state, ILS reliability has improved considerably over the years. Thus, assumptions made in 1976 about ILS system outage frequency are no longer valid.

Finally, reduction in ground delays from one runway at J.F.K. International Airport were used as a major justification for 1,250 MLSs nationwide. We understand that study results are expected soon as to whether a more cost effective solution exists for addressing the ground delays on this runway.

COLLOCATION OF MLS AND ILS SYSTEMS

FAA plans to collocate MLS and ILS systems during the transition period from one system to the other. Our work on the cost/benefit implications of this has raised issues about (1) the extent to which plans for locating MLS will maximize user benefits, and (2) the duration of the transition period and the effect this will have on estimated collocation costs in the cost/benefit analysis.

Collocation Benefits

As we understand the current implementation plan, FAA will collocate 104 of the first 178 MLSs (about 58 percent) on

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runways which already have an ILS, including 8 with ILSs that allow for precision landings in lower visability than MLS will permit. Meanwhile, about 90 runways that have been approved by FAA for precision landing capability will not be equipped either with ILS or one of the first 178 MLSs.

Because an analysis was not performed to compare the benefits of collocating the 104 MLSs on ILS equipped runways with the benefits of locating some of them on runways having no precision landing capability, it is possible that the current implementation plan minimizes benefits that otherwise might be attributable to MLS. Also, under the current implementation plan, airlines whose aircraft are ILS equipped may elect to continue to use the ILS to avoid the cost of retrofitting for MLS. Similarly, aircraft operators serving airports with no precision landing capability may see little incentive to purchase MLS.

We mention these factors due to the importance of user benefits to the cost/benefit analysis and, more fundamentally, to the MLS program justification. At the same time, however, we recognize that a range of factors, including maximizing benefits to users, will be taken into account by FAA in deciding where to site MLSs during the transition period and thereafter.

Collocation Costs

The length of time MLSs will be collocated on ILS equipped runways was an important cost factor in the original cost/benefit analysis. However, unless FAA plans to mandate the use of MLS, some ILSs may have to be located on the same runways as MLSs for a period of time beyond the 10 years for which ILS costs are included in the 1976 study. Based on our discussions with users, this is because the cost of on-board MLS avionics equipment may exceed the preceived benefits, especially for aircraft already equipped with ILS. If potential MLS users continue to use ILS rather than equip with MLS, the precision landing capability of these users will depend on the continued existence of ILS systems. Assuming this ILS capability is retained, the costs of collocating ILSs with MLSs could continue well beyond the 10-year transition period assumed in the 1976 study. Should this occur, MLS life-cycle costs would need to be increased to account for the additional costs of operating and maintaining redundant ILSs over a longer transition period.

DATA CURRENCY

Finally, we made observations during the briefing concerning the currency of study data on (1) in-flight

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versus ground delays, (2) the number of ILSs that cannot satisfy minimum precision landing requirements, (3) the cost of MLS and ILS ground equipment, and (4) the cost to equip air carrier and general aviation aircraft with MLS avionics equipment. As you know, this data has changed substantially over the years. FAA's efforts to update the study's data should enhance the validity of the new cost/benefit analysis.

We hope you find the observations in this letter of assistance in performing the MLS cost/benefit analysis. We are available to meet with you and your staff to further elaborate on the matters discussed in this letter. If you want to meet with us, or if we can be of any other assistance, please contact me on 366-1743 or Charles S. Cotton, Group Director, on 366-1827.

Sincerely yours,

Kenneth M. Mead
Associate Director

bc: Mr. McLure, RCED
Mr. Mead, RCED
Mr. Cotton, RCED
Ms. Hecker, RCED
Mr. Campbell, WRO
Job File

5

Reliability Data for ILS Components

Table III.I: Average Mean Time Between Outages for Fiscal Years 1979 and 1984

Outages in hours

	Localizer		Glide Slope	
	Unscheduled outages	Equipment outages	Unscheduled outages	Equipment outages
1979	1,760	4,594	2,383	7,028
1984	3,696	7,689	3,910	8,658

Table III.II: Mean Time Between Outages Fiscal Year 1985

Outages in hours

	Number	Unscheduled outages	Equipment outages
Localizer			
Tube-type	167	2,658	5,337
Solid-state			
All	695	4,501	8,897
Newer type[a]	413	5,349	11,035
Older type[b]	159	2,773	5,391
Other[c]	123	3,887	6,250
Glide slopes			
Tube-type	142	3,491	6,300
Solid state[d]	584	4,636	9,939

[a]FAA calls these Mark ID, IE, and IF

[b]Category I localizers older than those in footnote a

[c]Miscellaneous localizers including Category II and III

[d]Data not available to breakdown solid-state glide slopes between newer and older

Authoritative Views on the Importance of Operational Testing Prior to Production

OMB and DOT Guidance

OMB Circular A-109, dated April 1976, established policies for executive branch agencies in acquiring major systems. DOT Order 4200.14A, dated May 1978, prescribes the agency procedures for implementing A-109. Both the OMB circular and DOT order recommend a four-phased acquisition process following identification of a mission need: (1) identification and exploration of alternative design concepts, (2) demonstration of alternative design concepts, (3) full-scale development and limited production, and (4) full production. The development and limited production phase includes tests of system performance in the expected operational environment. Production decisions are usually based on the system's actual performance in the operational tests.

GAO Report on Aviation Systems Acquisition

Our March 1987 report on aviation acquisition found that FAA did not submit any of the 11 major system acquisitions in the NAS plan, including MLS, for DOT approval at either of the first two phases in the acquisition process.[1] FAA believed that these systems represented off-the-shelf technology and were sufficiently developed to be approved at either of the final two acquisition phases. The 11 systems, including MLS, experienced cost increases and/or schedule delays. GAO recommended that the FAA Administrator ensure that the major system projects not yet in the production phase be subjected to operational testing as recommended by OMB Circular A-109 and that the resulting data be made available for DOT's production decisions.

DOT, in replying to our report, maintained that it was firmly committed to operational tests and evaluations "where practicable" for all major system acquisitions. The agency added that operational test and evaluation plans are developed for each system and that an independent high-level review group within DOT, the Transportation System Acquisition Review Council, reviews all major system acquisitions to assure that the intent of the A-109 process and the GAO recommendation are followed.

Blue Ribbon Defense Panels

According to the July 1970 report of the President's Blue Ribbon Defense Panel,[2] operational testing helps predict in advance the operational capabilities and limitations of a system. The tests should take into

[1] Aviation Acquisition: Improved Process Needs to be Followed GAO/RCED-87-8, Mar. 26, 1987)

[2] Report to the President and the Secretary of Defense on the Department of Defense: Staff Report on Operational Test and Evaluation, Blue Ribbon Defense Panel, App. F, July 1970.

consideration the interface with other systems and equipment, organizational arrangements and human skills, and frailties of the eventual users.

The importance of the third phase in the acquisition process—full-scale development and limited production that includes operational testing—also was affirmed in the April 1986 Report of the President's Blue Ribbon Commission on Defense Management.[3] The report suggested that operational testing of major systems is critical and should continue through full-scale development. Systems should not go into high-rate production without benefit of operational test results.

FAA Consultant's Study

A 1984 FAA consultant's study of the test and evaluation programs for four FAA system acquisitions found, among other things, that failure to adequately test operational systems in realistic operational settings was a major cause of not surfacing and correcting problems prior to the systems' operational use.[4] The study includes a "lessons learned" section based on an analysis of the test and evaluation program histories of four FAA acquisitions during the time period 1969-1982.

One of the lessons learned is that FAA should require that systems be finally accepted only after testing them in a spectrum of air traffic control field operational environments or under realistic simulated conditions if possible and, with field operational personnel participating in the planning and test program. The consultant suggested that the lessons could be useful in the testing process for the NAS Plan projects.

[3] A Formula for Action: A Report to the President on Defense Acquisition, The President's Blue Ribbon Commission on Defense Management, Apr. 1986.

[4] MITRE Working Paper: Examination of Testing Activities for Selected FAA Programs, The MITRE Corporation, Aug. 1984.

Air Transport Association of America Position on MLS

Air Transport Association [ata] OF AMERICA

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Washington, D C 20006-5206
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March 10, 1988

WILLIAM F. BOLGER
President

The Honorable T. Allan McArtor
Administrator
Federal Aviation Administration
800 Independence Avenue, S.W.
Washington, D.C. 20591

Dear Allan:

During your January 21 speech before the National Aviation Club you noted the need for critical evaluation, updating and change to FAA's NAS Plan in order to keep pace with growth in civil aviation and rapid change in technology. You also expressed doubt that FAA has properly sold the benefits of the microwave landing system (MLS) and that the agency is seeking better ways to promote "the landing system of the future." The purpose of this letter is to request a revision of FAA's current position on precision approach aids -- the future roles of ILS and MLS. The ATA member airlines believe change is needed.

As you know, MLS is the second most costly element of the NAS Plan. The Plan envisions installation of 1200 MLS in the United States and replacement of ILS as the FAA standard precision aid. Airlines and some other airspace users have been growing increasingly concerned over the past few years that promised benefits of MLS will not be fully realized. The cost of MLS ground stations has escalated while serious technical problems have been experienced with ground system development. Additionally, FAA has seriously underestimated the total cost of the airborne systems retrofit that would be required for use in airline aircraft with sophisticated systems certificated for Category II/III operation using ILS as the guidance signal source. Many important technical improvements have been made in ILS in recent years that mitigate the shortcomings which motivated the development of MLS. Furthermore, the operational benefits of MLS have not materialized and current MLS technology offers less capability than ILS.

Ironically, ATA and its member airlines were among the strongest advocates -- in the late 1960's and early 1970's -- of the need to develop and implement a successor to ILS. We now believe the combination of increased MLS ground and airborne system costs and ILS improvements warrant consideration of a revised FAA landing aids program. Specifically, the ATA member airlines recommend that:

The Honorable T. Allan McArtor
Page 2
March 10, 1988

(1) The FAA NAS Plan be amended to reflect continuation of ILS as the primary U.S. precision approach guidance system with MLS playing a complementary, secondary role

(2) The ICAO protection date for ILS be extended beyond January 1, 1998, such that ILS can remain as the primary precision approach system. ICAO Standards and Recommended Practices for MLS should be completed and the system adopted as an internationally standardized secondary system for use at airports or on runways where ILS cannot meet the technical and operational needs of the users.

ATA and its member airlines are prepared to assist FAA in any analysis of the recommended landing aids program changes that may be needed and in any cooperative efforts that may facilitate such changes. Other users of the airspace and airports system should also be involved since the changes we recommend would affect all users.

We are aware that funds for the MLS second-buy were denied in the FY 1988 appropriation and FAA has undertaken a revised cost-benefit study of MLS. We also note that FAA has requested $20 million in the 1989 appropriations to pursue a MLS capability demonstration program. The Department of Transportation Inspector General and the General Accounting Office are also expected to publish studies relevant to the future role of ILS and MLS. We believe each of these actions will prove supportive of the need for the review we recommend.

We urge that the ILS/MLS program review be undertaken promptly. We also are mindful of the international obligations the United States may have under the ICAO ILS/MLS Transition Plan and believe that any revisions to the precision approach aid program that may be adopted by the United States should be communicated promptly to ICAO. Timely action by the U.S. is necessary so that any needed changes to ICAO Standards and Recommended Practices can be considered in an orderly manner and continued availability of ILS frequencies can be ensured.

Please advise me how we might best support FAA in this undertaking.

Sincerely,

William F. Bolger
President

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Related GAO Products

Federal Aviation Administration's Host Computer: More Realistic Performance Tests Needed Before Production Begins (GAO/IMTEC-85-10, June 6, 1985).

Installation of Automated Weather Observing Systems by FAA at Commercial Airports Is Not Justified (GAO/RCED-85-78, July 29, 1985).

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