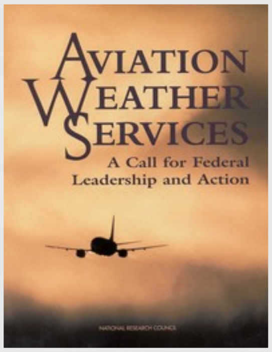

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Aviation Weather Services

A Call for Federal Leadership and Action

National Aviation Weather Services Committee
Aeronautics and Space Engineering Board
Commission on Engineering and Technical Systems
National Research Council

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This report has been reviewed by a group other than the authors according to procedures approved by a Report Review Committee consisting of members of the National Academy of Sciences, the National Academy of Engineering, and the Institute of Medicine.

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Preface

Each time we see grim pictures of aircraft wreckage on a rain-drenched crash site, or scenes of tired holiday travelers stranded in snow-covered airports, we are reminded of the harsh impact that weather can have on the flying public. Accordingly, the federal government, state governments, commercial air carriers, and a wide variety of aviation and meteorological professional and industry associations strive to improve the ability of the national airspace system to accommodate adverse weather. As part of this effort and at the request of the Federal Aviation Administration, the National Research Council established the Committee on National Aviation Weather Services during May 1994. The committee examined institutional issues that affect (1) the provision of national aviation weather services and (2) related research and technology development efforts. The committee's task statement consisted of five specific elements:

- Examine the roles played by various federal agencies in providing aviation weather services and in planning systems advances.
- Examine the roles of these agencies in research and development for those services.
- Assess the effectiveness of existing institutional arrangements to operate the current system and to plan and direct system improvements.
- Identify possible unmet needs (i.e., potential services or capabilities that may "fall through the cracks").
- Explore alternative approaches that might lead to improved weather monitoring and prediction for the aviation community ill both the Bear and long-term.

In order to assess the effectiveness of institutional arrangements, the committee first examined the adequacy of operational aviation weather services and related research. Although the committee did not focus on the effectiveness of individual aviation weather systems, it did determine how well current systems meet user needs. The committee then determined the extent to which the persistence of unmet needs and other problems could be attributed to shortcomings in institutional arrangements.

The committee concluded that user needs are well defined in earlier reports, federal documents, and interviews with knowledgeable members of the aviation and meteorological communities. In addition, the specific aviation weather functions that the Federal Aviation Administration, National Weather Service, Department of Defense, and other agencies currently provide seem to be well suited to their respective missions and capabilities. However, the committee did discover a lack of consensus and cooperation among many of the parties involved in providing and using aviation weather services. This fragmentation of responsibilities and resources leads to a significantly less-than-optimal use of available weather information. This report examines alternatives for responding to this situation. In particular, the report develops an approach whereby the federal government could provide stronger leadership to improve cooperation and coordination among aviation weather providers and users. The committee believes that stronger leadership is required for timely resolution of many key issues associated with aviation weather services and related research.[1] As such, stronger leadership should be viewed as an essential element of the overall effort to improve aviation weather services.

Given its specific tasking, the committee confined its analysis to the relatively specialized field of aviation weather services. That analysis, however, raised broader issues regarding institutional effectiveness within the Federal Aviation Administration. Such issues go beyond the purview of this committee. If the Federal Aviation Administration conducts a more-comprehensive analysis of overall institutional effectiveness, the committee recognizes that this might have implications for the way in which the recommendations of this report are implemented.

The study committee met five times between July 1994 and April 1995, collecting information, assessing relevant issues, and generating appropriate recommen

[1] See Appendix A for a complete list of the committee's findings and recommendations.

dations.[2] One of the goals of the committee was to ensure that its deliberations included a broad range of perspectives. To accomplish this goal, committee members conducted numerous additional meetings individually and in small groups in order to broaden the information collection effort and to discuss relevant issues with a wide variety of users and providers of aviation weather services. Committee members visited aviation weather and air traffic control facilities operated by the Federal Aviation Administration, National Weather Service, major air carriers, and private weather services in the vicinity of Washington, D.C.; Kansas City, Missouri; Boulder and Denver, Colorado; Boston, Massachusetts; Chicago, Illinois; and Dallas, Texas; and in communities throughout the state of Alaska. As pan of these meetings, committee members discussed aviation weather operations, research, and development with a wide variety of individuals, including pilots, meteorologists, air traffic controllers, flight service specialists, and current and former government officials from the Federal Aviation Administration, National Weather Service, National Transportation Safety Board, and National Oceanic and Atmospheric Administration. The committee wishes to thank all of these individuals, who are listed in Appendix C, for their contributions to the work of the committee. Finally, the committee wishes to express special appreciation and singular recognition to the study director, Alan Angleman, for his competence and diligence in every phase of its activities. His commitment to excellence leaves an indelible mark on this report. Alan was ably assisted by Ted Morrison in this effort. Ted's attention to a myriad of administrative and logistic issues made a significant contribution to the committee's successful conclusion of its task.

BRIG GEN ALBERT J. KAEHN, JR., USAF (RETIRED)
CHAIRMAN, COMMITTEE ON NATIONAL AVIATION WEATHER SERVICES

[2] See Appendix B for a list of committee members.

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Acronyms

ACARS	Aeronautical Radio Inc. (ARINC) Communications and Reporting System
AFSS	Automated Flight Service Station
ARTCC	Air Route Traffic Control Center
ASOS	Automated Surface Observing System
AWOS	Automated Weather Observing System
COMET	Cooperative Program for Operational Meteorological Training
CWSU	Center Weather Service Unit
DoD	Department of Defense
DUATS	Direct User Access Terminal Service
FAA	Federal Aviation Administration
FAR	Federal Aviation Regulation
FSL	Forecast Systems Laboratory
FSS	Flight Service Station
GAO	General Accounting Office
IFR	Instrument Flight Rules
MDCRS	Meteorological Data Collection and Reporting System
MIT	Massachusetts Institute of Technology
NASA	National Aeronautics and Space Administration
NCAR	National Center for Atmospheric Research
NOAA	National Oceanic and Atmospheric Administration
NTSB	National Transportation Safety Board
NWS	National Weather Service
OFCM	Office of the Federal Coordinator for Meteorology
OMB	Office of Management and Budget
PDT	Prospectus Development Team
RE&D	Research, Engineering and Development
RVR	Runway Visual Range
TDWR	Terminal Doppler Weather Radar
TRACON	Terminal Radar Approach Control
USWRP	U.S. Weather Research Program
VFR	Visual Flight Rules

Summary

Adverse weather has a major impact on aviation safety and efficiency. During 1988–1992, one-fourth of all aircraft accidents and one-third of fatal accidents were related to weather (Salottolo, 1994). In addition, 41 percent of air traffic delay time during 1990 was attributable to weather. These delays accounted for approximately $4.1 billion of direct costs to the airline industry—not including the financial loss and inconvenience suffered by the traveling public (OFCM, 1992). Projected increases in air travel will tend to exacerbate the impact of adverse weather on aviation safety and efficiency. Improving aviation weather services and related research is crucial if the national airspace system is to continue meeting public expectations for safety, efficiency, affordability, and convenience.

LEADERSHIP

THE PRIMARY RECOMMENDATION

The Federal Aviation Administration (FAA) should provide the leadership, establish the priorities, and ensure the funding needed to improve weather services for aviation users and to strengthen related research.[1]

Federal statutes clearly intend that the executive branch provide the weather services necessary to foster the safe and efficient use of the nation's airspace. In particular, Title 49 of the U.S. Code of Federal Regulations (Title 49) makes the FAA Administrator responsible for promoting the growth and development of a safe and efficient system of air commerce in the United States. The term "safe and efficient" appears many other times in Title 49, particularly with regard to FAA staffing, airspace usage, and research and development of new systems and procedures.

The committee concludes that federal responsibilities for ensuring aviation safety and efficiency and for providing aviation weather services are properly defined in existing legislation. Furthermore, the primary impediment to improving aviation weather services is not a lack of understanding regarding the types of services that users need or the areas of research that are needed to provide these services. Rather, there is a lack of consensus and cooperation among the government agencies, private weather services, research organizations, and user groups involved in aviation weather. Together, they have the resources to significantly improve aviation weather services, but they will achieve this goal only if they act in a concerted effort so that their individual actions are mutually reinforcing.

Vigorous leadership within the federal government and the personal accountability that comes with a sense of ownership are needed to build consensus and coordinate the overall effort to optimize aviation weather services and related research. Because aviation safety and efficiency are primarily the responsibility of the FAA, the FAA should provide this leadership. Other federal agencies, state governments, and the private sector should follow the FAA's lead to optimize current and future aviation weather systems and services.

The committee's recommendation that the FAA vigorously execute the lead agency role is the foundation for all of the other recommendations. The purpose of these recommendations is not to significantly increase the FAA's responsibility for providing or funding aviation weather services, systems, or related research. Instead, the recommendations are intended to improve the manner

[1] This summary describes the nine highest priority recommendations generated by the National Aviation Weather Services Committee. A complete list of the committee's Findings and recommendations appears in Appendix A. See Chapter 6 (page 55) for additional information on this recommendation.

in which the FAA and the rest of the federal government execute their current responsibilities for providing a safe and efficient system of air transport. For example, the National Weather Service (NWS) should continue to ensure the availability of accurate and comprehensive meteorological data and weather forecasts that meet the needs of pilots, controllers, and other aviation weather users.

As part of its effort to provide necessary leadership, the FAA should accomplish the following tasks:

- Specify national and regional aviation weather requirements.
- Organize multiagency participation in aviation weather research, operations, and training.
- Justify aviation weather budget requests.
- Orchestrate a coordinated aviation weather research and development program.
- Improve the understanding and use of weather information by aviation users.
- Provide day-to-day dissemination of weather information to aviation users.
- Respond to the recommendations contained in this report and in *Weather for Those Who Fly* (NRC, 1994).

To ensure that the FAA and other agencies accept the FAA's leadership role, the executive branch should formally designate the FAA as the lead federal agency responsible for the effectiveness and efficiency of the national aviation weather system. In response, the FAA should organize itself to take on this task vigorously. For example, the FAA Administrator should designate an associate administrator to assume overall responsibility for carrying out the FAA's lead agency role for aviation weather and to serve as a single focal point within the FAA with the authority to provide effective internal and external coordination of aviation weather services and related research programs that involve the FAA. In addition, the Office of Management and Budget (OMB), Department of Transportation, and Department of Commerce should expeditiously issue and implement updated or expanded policy directives to more fully comply with the intent of federal legislation regarding the provision of aviation weather services.[2]

SEPARATION OF AIRCRAFT FROM HAZARDOUS WEATHER

MAJOR RECOMMENDATION

The FAA should adopt the philosophy that weather services are an important part of its air traffic responsibilities; it should develop procedures and weather products to improve the ability of pilots and air traffic controllers to ensure that aircraft avoid hazardous weather.[3]

The FAA, which is heavily influenced by active and former air traffic controllers, seems to have developed a general cultural bias against increasing its involvement with weather and weather-related issues. During the next few years, however, advanced aviation weather services and systems could increase the accuracy and timeliness of weather information that is available to users of aviation weather services, including air traffic controllers. Such new services and systems would allow the FAA to enhance aviation safety by assuming a greater role in separating aircraft from hazardous weather.

Currently, the responsibility for keeping aircraft out of hazardous weather rests with pilots. However, as illustrated by accidents such as the 1994 crash of USAir Flight 1016 in Charlotte, North Carolina, pilots—and their passengers—would benefit if air traffic controllers were more cautious about clearing aircraft to operate in areas where hazardous weather is known to exist.[4] This is especially true in cases where controllers have weather information that is more current and complete than the information available to pilots. The committee recognizes that additional responsibilities associated with separating aircraft from weather should not interfere with the ability of controllers to carry out their current responsibility for separating aircraft from each other, which is also critical to aviation safety. The committee also accepts the need for pilots to retain ultimate responsibility for the safety of their aircraft. Nonetheless, in light of ongoing advances in weather observing and forecasting systems, the committee recommends that the FAA prepare to assume a greater role in separating aircraft from hazardous weather, including adjusting the functions of air traffic controllers to assist in this effort. As part of this effort, the FAA should work closely with other involved parties (e.g., pilots, owners, and operators of private and commercial aircraft) to ensure that proposed changes are likely to be effective and strike an appropriate balance between safety concerns and efficiency.

[2] In June 1994, the OMB canceled Circular A-62, which was the primary federal policy document on the provision of meteorological services and supporting research. The OMB appears to have taken this action without notifying or receiving the concurrence of affected federal agencies and without issuing new guidance in its place. It is not yet clear whether the OMB will replace Circular A-62.

[3] See Chapter 6 (page 56).

[4] A summary of the Charlotte accident appears immediately following this summary.

USER NEEDS

MAJOR RECOMMENDATION

The FAA should aggressively exercise its responsibility for coordinating user needs and expressing requirements for meteorological services to the NWS.[5]

The National Oceanic and Atmospheric Administration (NOAA) and the NWS properly view the FAA as the government agency with the expertise and experience to represent the interests of the aviation community. In fact, federal law directs the FAA administrator "to make recommendations to the Secretary of Commerce for providing meteorological service necessary for the safe and efficient movement of aircraft in air commerce" (Title 49).[6] In 1977, the FAA and NOAA approved a memorandum of agreement that established the following procedure to implement this requirement: "The FAA will continually review aviation weather requirements and the Secretary of Transportation will transmit at least annually to the Secretary of Commerce a letter of recommendations.... NOAA will then have an opportunity to respond to the FAA requirements and take appropriate planning and budgetary actions."

Developing a common understanding of aviation weather requirements between the FAA and NOAA is the critical first step in assessing current aviation weather services and in planning improvements. Although the FAA has worked with NOAA and the NWS on an ad hoc basis to develop some aviation-related weather systems, the FAA and Department of Transportation never have produced a formal, comprehensive list of aviation-related requirements for meteorological services in accordance with the 1977 agreement, which remains in effect. Piecemeal generation of these requirements is reflected in an aviation weather system that is similarly fragmented and, at times, unable to respond fully to the valid needs of pilots and other users.

The 1977 agreement also sought to improve interagency coordination by establishing high-level aviation weather liaisons between the FAA and NOAA. However, the position of NOAA Special Assistant for Aviation Affairs, which also reported to the FAA Administrator, was eliminated in 1978, and no position of comparable authority now exists within NOAA, the NWS, or the FAA.

Complying with existing procedures for interagency coordination of aviation weather requirements would facilitate development of an integrated approach to meeting the needs of aviation weather users. In addition, passing requirements through the Secretary of Transportation, the Secretary of Commerce, and the NOAA Administrator (as specified by the 1977 agreement) would give them the high-level attention they deserve.

NWS ROLES AND MISSIONS

MAJOR RECOMMENDATION

The NWS should continue to meet FAA-determined requirements for weather services as part of its responsibilities for atmospheric observations, analyses, and forecasts.[7]

The meteorological data collected by the NWS and the weather forecasts and warnings that it generates are essential parts of the aviation weather system. For example, only four U.S. passenger airlines operate their own meteorology departments; the rest depend upon weather forecasts and other products produced by the NWS and private weather services, which use data and information collected and/or generated by the NWS. Even those airlines that maintain their own meteorology departments work in partnership with the NWS to ensure the safety of the flying public. Airlines concentrate their forecasting efforts on their major hub airports; they depend upon NWS forecasts for most destinations. In addition, the NWS provides the FAA with the weather warnings that the FAA uses to alert pilots about dangerous weather conditions.

TRAINING

MAJOR RECOMMENDATION

The FAA should provide the leadership needed to develop a comprehensive national training program that improves the practical meteorological skills of users and providers of aviation weather services.[8]

Aviation weather training for pilots, air traffic controllers, aviation forecasters, flight service specialists, and dispatchers offers great potential for near-term reductions in weather-related accidents. This training is performed by many different public and private organizations. The

[5] See Chapter 2 (page 17).

[6] The NWS is part of NOAA, which is itself a component of the Department of Commerce. Thus, when discussing the duties and responsibilities of the NWS, some documents refer to the Department of Commerce or NOAA. The implication is that the Secretary of Commerce or the NOAA Administrator will execute weather-related tasks by assigning them, as appropriate, to the NWS.

[7] See Chapter 6 (page 57).

[8] See Chapter 3 (pages 35–38).

FAA, however, is responsible for establishing standards and licensing procedures for these professionals (except for forecasters, who fall under the jurisdiction of the NWS). Specific options for improving aviation weather education and training include the following:

- encouraging universities, flight schools, and other training facilities to focus initial and recurrent training of aviation weather users and providers on understanding and optimizing the use of available weather information;
- revising federal licensing procedures for pilots, controllers, flight service specialists, and dispatchers to test more effectively the abilities of candidates to use weather information in making safe operational decisions regarding the weather; and
- increasing the emphasis that weather receives during biennial flight reviews, safety seminars, and refresher courses for designated pilot examiners and flight instructors.

DISSEMINATION OF GRAPHIC WEATHER PRODUCTS

MAJOR RECOMMENDATION

The FAA should swiftly exploit current technology to provide consistent and timely graphic weather information to pilots, controllers, and dispatchers.[9]

The primary unmet user need associated with the current aviation weather system is the lack of widely distributed graphic weather products that would allow pilots, controllers, and dispatchers to develop and maintain a consistent view of current and forecast weather conditions. This situation persists even though current technology could provide this capability. For example, an airline passenger equipped with a laptop computer and a modern can use onboard telephones to obtain up-to-date graphic weather products via Internet or directly from private weather services. In many cases, these products are superior to the weather products that airline pilots can access from the cockpit. Recognizing that commercial systems do not involve the same rigorous flight safety and certification as cockpit communications systems, the committee urges the FAA to take the lead in improving the access of pilots and other users to advanced aviation weather products by fostering advances in three specific areas:

- graphic weather products;
- ground-to-air communications and cockpit display systems compatible with graphic weather products; and
- weather observations and forecasts with enhanced temporal, geographic, and altitude-specific resolution.

RESEARCH AND DEVELOPMENT

MAJOR RECOMMENDATION

The FAA should provide the leadership needed to support and focus research and development efforts by government, academic, and industrial institutions on key aviation weather issues.[10]

A number of individual research and development programs are aimed at improving the accuracy, timeliness, reliability, and relevance of aviation weather information. However, these programs are not adequately integrated with each other or with operational programs, and they suffer from funding uncertainties and lack of commitment by the government. The absence of clear priorities is a serious difficulty, one that is puzzling in view of the clarity with which the aviation community has repeatedly expressed its needs for improvements.

The committee concurs with an earlier recommendation by the National Research Council that the FAA and NWS should "develop an integrated program description specifying the objectives, strategies, schedule, phasing, and budgets to guide the ... development of a significantly improved [aviation] weather system" (NRC, 1994). Moreover, the committee urges the FAA to provide the leadership to respond to a recommendation by the Office of the Federal Coordinator for Meteorology that federal agencies develop an interagency plan for aviation weather research and development that will meet the following criteria:

- Encourage greater interagency coordination of research and development.
- Accelerate the transfer of research and development technology to operational use.
- Define needs for aviation weather observations, forecasting, dissemination, and preparation of weather products.
- Define the responsibilities of individual agencies for conducting research and development projects that fulfill these needs.

[9] See Chapter 3 (pages 38 and 39).
[10] See Chapter 4 (pages 45 and 46).

Many of the most significant weather hazards for aviation involve the various phases or changes in phases of water. Observations of atmospheric water vapor with greatly improved coverage, resolution, and accuracy would enable dramatic improvements in forecasts of thunderstorms; other convective activity; and cloud variables, such as ceiling height, cloud type, and icing potential. This committee concurs with other advisory groups, such as the National Research Council's National Weather Service Modernization Committee and an interagency panel convened by the Office of the Federal Coordinator for Meteorology, that have recommended increasing the priority for developing an effective system for high-resolution observations of atmospheric water vapor.

A strong program of aviation weather research, with specific priorities based on user needs, would contribute markedly to enhanced safety and efficiency of flight. In order for the federal government to meet its manifest responsibility to provide required aviation weather information for aviation and air travelers, it must manage such research creatively, responsibly, and effectively.

REGIONAL REQUIREMENTS

MAJOR RECOMMENDATION

The FAA should provide the leadership to meet regional needs for aviation weather services with regional solutions.[11]

Some geographic regions of the United States have environmental conditions and user needs that vary significantly from national norms in geographic density of weather observing sites, topography, availability of surface transportation, and other factors. These factors often reinforce each other. For example, mountainous regions generally have a high level of local weather variability, a low density of weather observing sites, and a sparse or nonexistent road network. This is particularly true in Alaska.

The federal system for providing aviation weather services is based on conditions and needs that prevail in much of the nation. In addition, funding constraints limit the resources that federal agencies can devote to meeting the aviation weather needs of regions with special environmental conditions. As a result, the federal aviation weather system, in some cases, does not fully respond to localized needs.

The FAA has a key role to play in meeting regional needs. Directly or indirectly, the FAA provides many aviation weather services, and it regulates the use of weather information by pilots, controllers, and dispatchers. Accordingly, the FAA should take the lead in finding the means to meet special regional needs for aviation weather services. For each region with special needs, the FAA should establish a team that includes other responsible federal and state government agencies, the local aviation industry, airport operators, professional organizations, and local communities to identify, assess, and properly respond to these needs. The FAA should also seek appropriate statutory and regulatory variances.

THE FIRST STEP

MAJOR RECOMMENDATION

The federal government should place a high priority on reaffirming and reinforcing the leadership role of the FAA and the supporting roles of other agencies.[12]

This report contains a variety of recommendations for increasing aviation safety and efficiency by improving the federal government's ability to satisfy the needs of aviation weather users. As noted, the recommendation for the FAA to assume a strong leadership role forms the foundation for all of the committee's other recommendations. This approach may seem simplistic, but it reflects the uncomplicated nature of the key shortcoming in the U.S. aviation weather system. The current system suffers primarily from a lack of coordination and focus. Strong leadership is needed to put in place a vigorous process for evaluating and implementing alternatives for improving the aviation weather system. Without this leadership, actions that could dramatically improve aviation weather services and related research are not likely to take place in a timely fashion, if at all. As a first step in achieving these improvements, the committee suggests the following timeline:

- Within 3 months of the release of this report, the FAA should implement the committee's recommendation to designate an associate administrator to assume overall responsibility for carrying out the FAA's lead agency role.[13]
- Within 6 months, the executive branch should replace OMB Circular A-62, which has been rescinded without replacement, by issuing "policy guidelines and procedures for planning and conducting Federal meteorological services and applied research and

[11] See Chapter 5 (pages 50 and 51).
[12] See Chapter 7 (page 61).
[13] See Chapter 6 (page 56).

development to improve such services" (OMB Circular A-62).[14]

- Within 9 months, the FAA and NOAA/NWS should comply with their existing memorandum of agreement regarding the provision of aviation weather services, or they should implement a new agreement.[15]
- Within 12 months, with the assistance of the Office of the Federal Coordinator for Meteorology, the FAA should prepare a definitive 5-year integrated plan specifying the objectives, strategies, schedule, phasing, and budgets needed to achieve an improved aviation weather system. This plan should be developed with inputs from other government agencies and the user community.

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[14] See Chapter 2 (page 16) and Appendix D (page 78).

[15] See Chapter 2 (pages 16–19).

USAIR FLIGHT 1016—A SUMMARY OF THE NATIONAL TRANSPORTATION SAFETY BOARD'S FINAL REPORT

On the evening of July 2, 1994, USAir flight 1016 crashed during approach to Charlotte/Douglas International Airport. This accident illustrates the direct impact that the aviation weather system can have on the flying public. The National Transportation Safety Board (NTSB) investigation generated 16 recommendations for the FAA, NWS, and USAir. These recommendations focus on the need for (1) more accurate observations and forecasts of hazardous weather conditions, (2) more timely and complete dissemination of hazardous weather information from meteorologists to air traffic controllers and from air traffic controllers to pilots, and (3) improved pilot training programs that increase the ability of pilots to quickly recognize and properly respond to hazardous weather that they encounter. These recommendations are consistent with the key recommendations of the Committee on National Aviation Weather Services, as documented in this report.

Chronology

During the approach, the captain and first officer discussed the poor weather conditions with each other and with the approach controller. The captain and first officer also discussed the possibility of having to abort the landing because of the weather.

At 6:39 p.m., the captain of USAir flight 806, who was ready to take off, advised the tower controller that he would hold because of "a storm right on top of the field." About 30 seconds later, the tower controller cleared flight 1016 to land. The captain of flight 1016, who could see rain adjacent to the airport, immediately asked the tower for a report from the plane that had just landed ahead of him. At 6:40 p.m., the tower controller reported that the previous aircraft had experienced a "smooth ride." Flight 1016 was less than 4 miles from the runway.

At 6:41 p.m., the tower controller broadcast a windshear alert and cleared another aircraft to land behind flight 1016.[1] At this time, USAir flight 797 was ready to take off behind flight 806. The tower controller asked the captain of flight 797 if he wanted to move ahead of flight 806 and take off. The captain of flight 797 responded that he, too, would hold on the ground. Flight 1016 was less than 2 miles from the runway.

At 6:42 p.m., just a few seconds after flight 1016 encountered rain that sharply decreased visibility, the captain ordered his first officer to initiate a missed approach. The captain and first officer did not yet recognize that they had encountered severe windshear (i.e., a microburst) bemuse (1) the aircraft did not experience turbulence typical of windshear and (2) the aircraft's windshear warning system had not alarmed. Subsequent analysis indicated that flight 1016 encountered windshear of 61 knots.

Seventeen seconds after initiating the missed approach, flight 1016 hit the ground. Airspeed at the time of impact was 150 knots. The captain and one flight attendant received minor injuries. The first officer, 2 flight attendants, and 15 passengers received serious injuries. The remaining 37 passengers died.

Causes

The NTSB determined that the probable causes of this accident were as follows:

- The flightcrew's decision to continue an approach into severe convective activity that was conducive to a microburst.
- The flightcrew's failure to recognize a windshear situation in a timely manner.
- The flightcrew's failure to establish and maintain the proper airplane attitude and thrust setting necessary to escape the windshear.
- The lack of real-time adverse weather and windshear hazard information dissemination from air traffic control.

The NTSB identified the following contributing factors:

- The lack of air traffic control procedures that would have required the controller to display and issue ASR-9 radar weather information to the pilots of flight 1016.
- The Charlotte tower supervisor's failure to properly advise and ensure that all controllers were aware of and reporting the reduction in visibility and runway visual range and the low level windshear alerts that had occurred in multiple quadrants.
- The inadequate remedial actions by USAir to ensure adherence to standard operating procedures.
- The inadequate software logic in the airplane's windshear warning system (which delays warnings when flaps are in motion) that did not provide an alert upon entry into the windshear.

Source: NTSB, *Abstract of Final Report—USAir Flight 1016*, NTSB Public Meeting, April 4, 1995.

[1] Windshear involves a sudden shift in wind speed and direction. When aircraft are operating at low speed and altitude (i.e., shortly before landing and after take off), windshear can severely alter aircraft performance. The FAA and air carriers have invested heavily in windshear detection and avoidance systems to reduce the hazard posed by windshear. For example, the FAA has developed the Low Level Windshear Alert System and Terminal Doppler Weather Radar (TDWR) to improve the ability, of air traffic controllers at airports to detect windshear and warn pilots. A TDWR system would nave been operational at the Charlotte airport prior to the crash of flight 1316 if the FAA had installed it on schedule. However, installation of the Charlotte TDWR was delayed when the FAA experienced unexpected problems in acquiring land for the proposed site.

1

Introduction

Adverse weather has a major impact on aviation safety and efficiency.

Aviators and their flying machines have had to cope with adverse weather since the dawn of aviation. A major factor in the Wright brothers' selection of Kitty Hawk, North Carolina, as their test site was the expectation of favorable winds. Nonetheless, on the historic day when they first demonstrated powered flight, a wind gust overturned and damaged their aircraft after its fourth flight.

Today, weather continues to be one of the most important factors affecting aviation safety and efficiency. During 1988–1992, one-fourth of all aircraft accidents and one-third of fatal accidents were related to weather (Salottolo, 1994). In addition, 41 percent of air traffic delay time during 1990 was attributable to weather. These delays accounted for approximately $4.1 billion of direct costs to the airline industry—not including the financial loss and inconvenience suffered by the traveling public (OFCM, 1992). Projected increases in air travel will tend to exacerbate the impact of adverse weather on aviation safety and efficiency.[1] Efficiently managing the research, development, acquisition, and operation of aviation weather systems and services is essential to accommodate increased air traffic while continuing to meet public expectations for safety, efficiency, affordability, and convenience.

The skill and experience of pilots involved in U.S. aviation vary widely, as do the capabilities of their aircraft. Thus, the aviation weather system must provide a wide variety of services to accommodate the needs of individual pilots as well as those of the air traffic controllers, airline dispatchers, flight service specialists,[2] aviation weather forecasters, and airport managers upon whom they depend.

Assessing the effectiveness of existing aviation weather services and related research is a difficult task. Although many accidents are related to weather, the number and frequency of accidents are an imperfect and incomplete measure of effectiveness for two reasons. First, although many weather-related accidents could be reduced by improving the quality of preflight and en route aviation weather services, weather-related accidents also could be reduced by enhancing training programs to increase the effectiveness of decision making by pilots, controllers, and other users in the face of uncertain or adverse weather conditions. Second, adverse weather can create dangerous situations that, because of pilot skill, luck, or some other circumstance, do not result in aircraft accidents or reportable incidents, and these situations do not appear in accident statistics. Similarly, the efficiency of aviation operations is a product of many diverse factors, and it is difficult to isolate the specific impact of aviation weather services.

An earlier report, *Weather for Those Who Fly* (NRC, 1994), examined the existing conceptual and technological possibilities for improving aviation weather services, most notably by providing accurate, timely, and relevant information in graphic format to pilots (on the ground and in the air), air traffic controllers, and other users. Finding that "the present-day aviation weather system is obsolete," that report argued that "the needs of aviation for a modern weather information system are manifold and urgent." The report also offered a "vision of an improved weather system [that] includes modernized observation systems, new capabilities in high-resolution atmospheric modeling and prediction, new data bases designed to meet aviation needs, and a new emphasis on presenting weather information in ways that aid effective decision making by pilots, air traffic controllers, and dispatchers." Because "there is no single, integrated plan specifying the objec

[1] Operations by U.S. air carriers are projected to grow by over 50 percent between 1995 and 2006 (FAA, 1995b).

[2] Flight service specialists staff flight service stations, which are operated by the Federal Aviation Administration (FAA). Flight service specialists file flight plans, provide pilots with preflight weather briefings, and communicate with pilots en route regarding weather and muting. General aviation pilots are the primary users of flight service stations.

tives, strategies, schedule, phasing, and budgets" to achieve an improved aviation weather system, the report concluded that "the vision is clear, the commitment to realize it is not." Thus, the report recommended that because "the initiatives for improving weather information services to all sectors of aviation address urgent needs and take advantage of existing technology, they should be pursued with resolve and implemented surely and swiftly."

The report of this committee turns to questions related to how the federal government can meet its responsibilities to provide aviation weather services "surely and swiftly." The report is not concerned with the science and technology of aviation weather information. Rather, it focuses on the roles and missions of the Federal Aviation Administration (FAA), the National Weather Service (NWS), other agencies, and the private sector. Also, the report documents the need for greater federal leadership in aviation weather services and presents a variety of recommendations that could result in significant improvement at little or no additional cost.

SAFETY IMPERATIVES

The U.S. airspace system is one of the safest in the world. In fact, aviation is the safest means of passenger transportation in United States (DOT, 1990). Nonetheless, as illustrated in Table 1–1, weather-related accidents frequently end in tragedy. During 1988–1992, the annual death toll from aircraft accidents in the United States was 1,016 people, and weather was a cause or factor in one-third of fatal aircraft accidents (Salottolo, 1994). Accordingly, accident prevention is a primary goal of the aviation weather system. This emphasis is reflected in the FAA's strategic plan (FAA, 1994b), which includes two weather-related objectives:

- "Reduce the likelihood of weather-related accidents by improving access and delivery of weather information and by improving technology."
- "Reduce the capacity-impacting consequences of weather phenomena by improved weather forecasts and increased accuracy, resolution, and dissemination of observations on the ground and in the air."

In addition, the 1993 FAA Capital Investment Plan establishes the goal of reducing "the number of accidents attributable to weather by 20 percent by 2000" (FAA, 1993).

ECONOMIC IMPERATIVES

The air transportation system serves the business community and general public by providing routine passenger service and delivering mail and other air cargo throughout the United States. The pervasive impact of aviation on the U.S. economy is reflected in the following data:

- U.S. air carriers generate annual revenues of $88 billion per year (FAA, 1995).
- The United States has about one-half of the world's aviation activity. Fourteen of the world's 15 busiest commercial airports are located in the United States (DOT, 1994).
- Passenger-miles flown by U.S. air carriers more than doubled between 1979 and 1994. More than a million people fly in the United States every day. During 1993, U.S. air carriers accumulated 11 million flight hours, served 513 million passengers, moved about 18 billion ton-miles of cargo, and consumed 16 billion gallons of fuel (FAA, 1995).
- During 1993, general and business aviation aircraft, including air taxis and helicopters, accumulated 24

TABLE 1-1 Accident Statistics, 1988–1992 (Source: Salottolo, 1994)[a]

	Annual Average Number of Accidents	Weather-Related Accidents	Annual Average Number of Fatal Accidents	Percent of Fatal Accidents That Are Weather-Related
General Aviation	2,210	24%	440	30%
Major Air Carriers	25	25%	6	21%
Commuters and Air Taxis	115	32%	31	45%

[a] Additional information on weather-related aircraft accidents is contained in Table 4–1 of *Weather for Those Who Fly* (NRC, 1994).

TABLE 1-2 U.S. Airports with Annual Delays in Excess of 20,000 hours (Source: FAA, 1994a)

Atlanta Hartsfield	Minneapolis-St. Paul
Boston Logan	New York Laguardia
Charlotte Douglas	Newark International
Chicago O'Hare	Orlando McCoy
Dallas-Fort Worth	Philadelphia International
Denver Stapleton	Phoenix Sky Harbor
Detroit Metro Wayne	Pittsburgh International
Honolulu International	San Francisco International
Houston International	Seattle-Tacoma
John F. Kennedy International	St. Louis Lambert
Los Angeles International	Washington National
Miami International	

- million flight hours and consumed 719 million gallons of fuel (FAA, 1995).
- In some areas of the United Sates, including most of Alaska, aviation is the primary means of transportation.
- U.S. commercial, business, and general aviation involves over 185,000 aircraft; 665,000 licensed and student pilots; and 100,000 flight hours per day (FAA, 1995).

Just as aviation is an important element of the U.S. economy, aviation weather services are an important component of the air transportation system, as indicated by the following:

- The accuracy of high-level wind forecasts has a significant impact on fuel consumption. Improved forecasts could reduce the amount of fuel consumed by air carriers by 1–3 percent (NASA, 1982).[3] During 1993, this would have saved U.S. carriers up to $300 million.
- Widespread use of cockpit weather display systems would reduce the annual operating costs of a typical domestic airline by $5.9 million (Scanlon, 1993).
- Forecasts of adverse weather at destination airports often require departing aircraft to carry extra fuel so that they can reach alternate airports in case they cannot land at the intended destination. A typical commercial jet aircraft burns approximately 1 percent of the added fuel for every 100 miles it flies. Thus, if 700 pounds of extra fuel are added to a flight of 1,000 miles, about 70 pounds of extra fuel are consumed just to carry the added weight. However, it is not unusual for forecasts to predict adverse weather that is not present when aircraft arrive at their destination. Improved weather forecasts would reduce these "false alarms" and, thereby, reduce the need to carry—and consume—extra fuel.

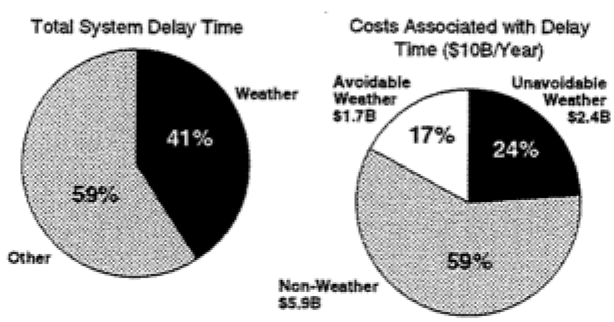

Figure 1-1 Cost of weather-related aviation delays during 1990. (Source: OFCM, 1992)

- Adverse weather in the vicinity of airports is the primary cause of aviation system delays as well as a principal cause of air carrier accidents. During 1993, the 23 U.S. airports listed below in Table 1-2 each experienced more than 20,000 hours of aircraft delay. Without increases in system capacity, annual delays at nine additional airports are projected to reach this level by 2003 (FAA, 1994a). Many of these airports operate at or near capacity for several hours each day. *As a result, even minor weather events can cause significant delays* (Qualley, 1995).
- Figure 1-1 depicts the total estimated cost of avoidable delays associated with weather during 1990. Small increases in airport capacity during adverse weather can significantly reduce the total system delays that result.[4] For example, increasing airport capacity by 10 percent during adverse weather may yield a 20–50 percent reduction in total system delays. Likewise, small reductions in the effective duration of adverse weather (e.g., from 3 hours to 2.5 hours), which can be realized by more accurately predicting when the adverse weather will start and end, can reduce total system delays by a substantial amount (20–35 percent) (Evans, 1995).

[3] More recent studies, which have examined oceanic flights, indicate possible savings of 0.6–2.9 percent. Actual savings for shorter flights would probably be less (Tenenbaum, 1992; Lunnon and Ahmed, 1993).

[4] Airport capacity refers to the number of aircraft that can take off or land per hour. As weather conditions deteriorate, airport capacity decreases because of changes in air traffic procedures and aircraft separation standards. In addition, flight-crew management of aircraft is more conservative. For example, during conditions of low visibility, spacing intervals between aircraft are increased and aircraft taxi at lower speeds. Advanced air traffic control systems and advanced avionics can improve airport capacity by allowing more aircraft to operate safely even in conditions of reduced visibility.

- Deicing operations at a major facility such as Denver International Airport can cost about $220,000 for a 24-hour snowstorm. Improving the ability to predict and measure snow accumulation and precipitation rates allows airlines to reduce these costs (and the environmental impact posed by deicing fluids) by tailoring their deicing operations to actual conditions (Carmichael, 1995).

Air traffic controllers ensure that aircraft under their control maintain safe separation distances from each other. During adverse weather, airline despatchers and air traffic managers reduce air traffic to prevent overloading airports. Improving aviation weather services makes it possible for these individuals to respond more appropriately to adverse weather, thereby reducing weather-related delays and increasing the capacity and efficiency of the national airspace system. As a result, the quality of aviation weather services has a direct impact on the growth and maintenance of a safe and efficient system of air commerce in the United States.

ORGANIZATION OF THIS REPORT

Together with Chapter 1, Chapter 2 lays the foundation for the rest of the report. Chapter 2 (and Appendix D) describes the aviation weather roles and missions of federal agencies as defined by existing legislation, interagency agreements, and Federal Aviation Regulations (FARs). Chapter 2 also briefly discusses aviation weather-related issues associated with proposals to establish an air traffic services corporation to take over some of the functions of the FAA.

Chapter 3 (and Appendices E through G) assesses the effectiveness of currently available aviation weather services and related training programs. Chapter 3 uses these assessments to identify unmet user needs that should be addressed by improving existing systems and fielding new systems. Chapter 4 (and Appendix H) builds upon Chapter 3 by investigating issues associated with the aviation weather research and development program and its ability to provide a knowledge and technology base that will keep pace with future growth in user needs.

Chapter 5 (and Appendix I) is devoted to regional requirements, how they vary from national norms, and how well the national aviation weather system meets regional needs.

Chapters 6 and 7 contain the main message of the report. Chapter 6 (and Appendix J) assesses options for adjusting agency roles and missions in light of the intent of current legislation and the effectiveness of existing national and regional aviation weather services and related research. Chapter 7 describes several near-term activities to initiate the process of improving the ability of the aviation weather system to meet its current and future potential in terms of safety and efficiency.

Appendix A contains a complete list of the committee's findings and recommendations.

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2

Current Roles and Missions

Federal statutes intend that the executive branch provide the weather services necessary to foster safe and efficient use of the nation's airspace. Because this intent is not being fully realized, the executive branch should issue appropriate policy directives and comply with them.

Federal roles and missions for aviation weather services and related research are divided among the FAA; NWS and National Oceanic and Atmospheric Administration (NOAA); Office of the Federal Coordinator for Meteorology (OFCM); and the National Aeronautics and Space Administration (NASA) in accordance with the following key documents:

- Organic Act of 1890, as amended, which in its current form establishes the NWS as a civilian agency within the Department of Commerce;
- Federal Aviation Act of 1958, as amended, which in its current form assigns responsibilities to federal agencies for a wide range of aviation activities, including aviation weather services;
- National Aeronautics and Space Act of 1958, as amended, which in its current form establishes NASA;
- Department of Commerce Appropriations Act of 1963, which established requirements for summarizing government-wide budgetary items associated with meteorology;
- Weather Services Modernization Act, Title VII of Public Law 102–567, October 1992, which requires the Secretary of Commerce to certify that the process of modernizing the NWS will not degrade local weather services;
- Office of Management and Budget (OMB) Circular A-62, November 13, 1963, and the Department of Commerce Implementation Plan for Circular A-62, January 9, 1964, which established policy guidelines for federal meteorological services and applied research and development; and
- Memorandum of Agreement Between the FAA and the NOAA for the Establishment of Working Arrangements for Providing Aviation Weather Service and Meteorological Communications, January 24, 1977.

The first five documents listed above establish legislative requirements and responsibilities for aviation weather services. The executive branch generated the last two documents to establish a process for implementing those requirements. Relevant portions of each of these documents appear in Appendix D (page 74).

LEGISLATIVE REQUIREMENTS

Title 49 of the U.S. Code of Federal Regulations (Title 49), which includes the Federal Aviation Act of 1958 (as amended), requires the Secretary of Commerce to establish weather offices, make weather observations, collect and distribute pilot weather reports, generate forecasts, and conduct appropriate science and research projects "in order to promote safety and efficiency in air navigation *to the highest possible degree*."[1] The Secretary is required to take these actions in addition to weather-related activities performed for other purposes. Furthermore, the Secretary is directed to "avoid duplication of services [with other agencies of the federal government] *unless such duplication tends to promote the safety and efficiency of air navigation*."

Title 49 directs the FAA Administrator "to make recommendations to the Secretary of Commerce for providing meteorological service necessary for the safe and

[1] Emphasis has been added here and in the following quote.

efficient movement of aircraft in air commerce."[2] Title 49 contains additional language that indirectly requires the FAA to take an interest in weather that goes beyond simply identifying what meteorological services are needed by aviation. In particular, Title 49 requires the FAA Administrator to "develop plans for and formulate policy ... to insure the safety of aircraft and the efficient utilization of [the navigable] airspace." Title 49 also directs the FAA Administrator to formulate long-range research and development plans, conduct or supervise research, and develop the systems and procedures needed to enhance aviation safety and efficiency, particularly with regard to the performance of pilots and air traffic controllers. The term "safe and efficient" appears many other times in Title 49, particularly with regard to FAA staffing, airspace usage, and research and development of new systems and procedures.

The committee generated the following finding and general recommendation concerning FAA responsibilities for weather services. (The committee's findings and general recommendations appear throughout the report as separate paragraphs in italic text. In addition, the committee's nine major recommendations are numbered and boxed. Appendix A lists all of the committee's findings and recommendations.)

Finding: *Federal regulations create an implicit responsibility for the FAA to ensure that weather services are available to meet the needs of aviation.*

Recommendation: *The FAA should view meteorology as a significant component of every area of its responsibility in which weather could affect safety or efficiency.*

Safety issues—and the publicity associated with air crashes and passenger fatalities—often motivate the government to take aggressive action to improve safety. However, Title 49 repeatedly mentions *both safety and efficiency* as goals that the FAA and the Department of Commerce (i.e., the NWS) should have for the national airspace system and related aviation weather services. For example, Title 49 plainly states that "the Administrator shall develop, modify, test, and evaluate systems, procedures, facilities, and devices ... to meet the needs for safe and efficient navigation and traffic control...." Although increases in efficiency should not come at the expense of safety, Title 49 clearly implies that the FAA should develop new systems and procedures that increase the efficiency of air commerce. Low efficiency creates unnecessary passenger delays, increases costs, and interferes with long-term efforts to improve the financial stability of U.S. air carriers.

Recommendation: *The FAA should aggressively strive to improve the efficiency of air commerce just as it already strives to improve safety*.

The National Aeronautics and Space Act of 1958, as amended and incorporated into Title 42 of the U.S. Code of Federal Regulations, specifies that NASA's mission includes fundamental research and technology development activities in aeronautical disciplines to improve the safety and efficiency of the U.S. air transportation system. NASA's mission also includes the provision of technical assistance and facility support to other government agencies and the private sector. For example, NASA recently completed a technology development program for airborne windshear detection and avoidance technology. Other ongoing NASA programs are focused on the impact of reduced visibility and cloud ceilings on airport operations, methodologies for designing aircraft with improved icing resistance, and nowcasting volcanic hazards and upper-air winds (Schlickenmaier, 1994). NASA and the FAA use the FAA-NASA Coordinating Committee to facilitate the coordination of research programs of common interest to NASA and the FAA.

As part of the ongoing NWS Modernization Program, the NWS is relocating many of its local weather offices and installing new systems such as weather radars and automated observing systems. These changes directly impact the ability of the NWS to provide aviation weather services. In order to ensure that these changes do not degrade local weather services, the U.S. Congress included specific conditions within the Weather Services Modernization Act that the Secretary of Commerce and Secretary of Transportation must meet prior to closing weather service field offices or replacing airport weather observers with automated weather observing systems.[3]

The Department of Commerce Appropriations Act of 1963 established a requirement for the Bureau of the Budget to include in each year's budget presentation a summary of all federal programs for meteorology, including goals and expected costs. This requirement, which has

[2] The NWS is part of NOAA, which currently is itself a component of the Department of Commerce. Thus, when discussing the duties and responsibilities of the NWS, some documents refer to the Department of Commerce or NOAA.

[3] The Weather Services Modernization Act does not allow the NWS to close or relocate any weather service field office that is located at an airport unless the Secretary of Commerce "in consultation with the Secretary of Transportation ... determines that such action will not result in degradation of service that affects aircraft safety." The act also does not allow the NWS to "commission an automated surface observing system located at an airport unless it is determined, in consultation with the Secretary of Transportation, that the weather services provided after commissioning will continue to be in full compliance with applicable flight aviation rules promulgated by the Federal Aviation Administration."

been retained in Title 68 of the U.S. Code of Federal Regulations, now applies to the OMB.

Finding: *Federal responsibilities for ensuring aviation safety and efficiency and for providing aviation weather services are adequately defined in existing legislation*.

IMPLEMENTATION BY THE EXECUTIVE BRANCH

Shortcomings in the implementation of legislative policy by the executive branch are illustrated in the following discussions of (1) OMB Circular A-62 and (2) the current FAA/NOAA memorandum of agreement regarding the provision of aviation weather services.

OMB Circular A-62

Circular A-62 and the Department of Commerce Implementation Plan for Circular A-62 were issued on November 13, 1963, and January 9, 1964, respectively, to facilitate compliance with the new legislative requirement to develop a comprehensive, interagency budget presentation for meteorology.[4] Circular A-62 and the Department of Commerce Implementation Plan established the OFCM (Office of the Federal Coordinator for Meteorology) as a catalyst for interagency coordination with regard to planning and reviewing meteorological services and supporting research across the federal government. The implementation plan also established a high-level federal committee to work with and provide policy guidance to the OFCM and to assist in resolving interagency disputes.

The mission of the OFCM is to provide systematic coordination and promote cooperation among federal agencies. However, Circular A-62 and the Department of Commerce Implementation Plan do not authorize the Federal Coordinator to *demand* interagency cooperation or to direct the operational actions of federal agencies with regard to meteorological services or related research. Instead, the Federal Coordinator relies on the *voluntary* cooperation of federal agencies (Wright, 1995). In addition, the Federal Coordinator can recommend that OMB reduce funding for specific meteorological projects if it appears that they are not being coordinated with related efforts by other agencies.

Circular A-62 made the Department of Commerce responsible for basic meteorological services, but it made user agencies responsible for specialized meteorological services to meet the needs of user groups such as aviation. As defined by Circular A-62, the goal of basic meteorological services was to (1) meet the needs of the general public, (2) protect their lives and property, and (3) make available a common set of processed meteorological data that describes the current and forecast state of the atmosphere. Basic meteorological services did not include generation of weather products to meet the operational needs of specialized user groups. *Because it does not include aviation weather services as one of the core responsibilities of the Department of Commerce, Circular A-62 seems to have been inconsistent with sections 310 and 803 of the Federal Aviation Act of 1958, as amended* (see Appendix D, page 76).

Circular A-62 remained unchanged and in force until June 1994, when OMB canceled it, apparently without notifying or receiving the concurrence of affected federal agencies and without issuing new guidance in its place. In the absence of such guidance, the OFCM and other federal agencies involved in meteorological services and supporting research are continuing to function in accordance with Circular A-62 to fulfill the relevant requirements of Title 68, which remains in effect. As of August 1995, OMB had not yet determined whether it would replace Circular A-62 with new guidance or whether new guidance, if forthcoming, would resolve the apparent inconsistency between Circular A-62 and federal legislation.

FAA/NOAA Memorandum of Agreement

The *Memorandum of Agreement Between the FAA and the NOAA for the Establishment of Working Arrangements for Providing Aviation Weather Service and Meteorological Communications, January 24, 1977*, defines a specific, comprehensive approach by the FAA and NWS for providing aviation weather services. Although the FAA and NWS concur that a new agreement is needed, the 1977 agreement has not been formally rescinded, and the near-term prospects for approving a new agreement remain uncertain. Thus, this report discusses the 1977 agreement rather than the unapproved draft of the proposed new agreement.[5]

The approach defined by the 1977 agreement involves close cooperation between the FAA and NWS, as indicated by the following elements of the agreement:

[4] Circular A-62 was issued by the Bureau of the Budget, the predecessor of the OMB.

[5] The initial draft of the 1977 agreement was produced in 1969, but it was not finalized until 1977. The first effort to produce a revised agreement started during the mid-1980s and failed to culminate in a new agreement. Another effort to produce an updated agreement began about 1990. This effort is continuing. The slow pace of completing a new agreement seems to derive primarily from a lack of consensus within the FAA regarding aviation weather policy and the low priority that the FAA assigns to resolving most weather-related issues.

- Each year, the Secretary of Transportation will send a letter to the Secretary of Commerce that defines (1) weather services needed to provide a safe and efficient system of air commerce and (2) aviation weather research and development requirements.
- The FAA and NOAA will jointly review existing and planned programs at least annually and agree on a program plan to meet the research and development requirements contained in the above letter.
- The FAA and NOAA will consult with each other regarding all long-range planning for aviation weather services, and they will coordinate all matters having to do with making and reporting weather measurements relevant to aviation.
- The FAA and NOAA will designate an official from each agency to act as formal liaisons.
  - — The NOAA Special Assistant for Aviation Affairs will report to both the FAA Administrator and the NOAA Administrator. This official will assist in defining operational requirements for aviation weather, coordinating aviation weather activities within the FAA, and evaluating user needs.
  - — A representative of the FAA's research and development activity will work with the NWS to coordinate requirements for aviation weather research and development and help resolve interface problems with FAA and NWS systems.
- The FAA and NOAA will occupy adjacent quarters at the same airport whenever advantageous.

As discussed below, the FAA and NWS no longer execute key elements of the agreement that are directly related to (1) defining aviation weather requirements and (2) interactions between the FAA and the NWS.

Defining Aviation Weather Requirements

NOAA and the NWS properly view the FAA as the government agency with the expertise and experience to represent the interests of the aviation community. Thus, even though the NWS plays a key role in providing aviation weather services, it has very little direct interaction with the aviation community regarding user requirements. Instead, the NWS relies almost entirely upon the FAA to validate user needs. However, since the memorandum of agreement was signed in 1977, the Secretary of Transportation has never complied with the requirement to advise the Secretary of Commerce regarding the need for aviation weather services and research. This shortcoming may reflect the concern of some former and current FAA officials that stating weather requirements may create an implied obligation to fund additional aviation weather services and related research.

The FAA does pass some requirements for aviation weather services and research directly to the NWS on an ad hoc basis. However, the NWS has not always been well served by this approach. Piecemeal generation of requirements is reflected in an aviation weather system that is similarly fragmented and, at times, unable to respond fully to the valid needs of pilots and other users. For example, the NWS now realizes that the FAA did not serve as an effective intermediary between the NWS and aviation weather users with regard to generating performance requirements for the Automated Surface Observing System (ASOS).[6] Partly as a result of this situation, the NWS has had to augment some ASOS units with human weather observers and develop plans for increasing the capabilities of deployed ASOS units to meet aviation needs.

Complying with the procedures established by the 1977 memorandum of agreement for interagency coordination of aviation weather requirements would facilitate development of an integrated approach for meeting the needs of aviation weather users. In addition, passing requirements through the Secretary of Transportation, the Secretary of Commerce, and the NOAA Administrator (as specified by the 1977 agreement) would help ensure that they receive the high-level attention they deserve.

Finding: *Developing a common understanding of aviation weather requirements between the FAA and NOAA is the critical first step in assessing current aviation weather services and planning improvements*.

MAJOR RECOMMENDATION 1

The FAA should aggressively exercise its responsibility for coordinating user needs and expressing requirements for meteorological services to the NWS.[7]

Interactions Between the FAA and the NWS

The location of the NWS and FAA in different executive departments complicates the process of coordinating their efforts. One of the motivations for transfer

[6] Over 500 ASOS units are now installed across the country. The NWS and FAA anticipated that these units, together with other weather system improvements, would allow the NWS to eliminate human weather observers at many airports. However, as discussed in Chapter 3 (page 25) and Appendix E (page 82), many aviation weather users perceive that replacing human weather observers with automated systems, as they are currently designed and operated, reduces the overall quality of surface weather observations.

[7] This is one of the committee's nine major recommendations, all of which are boxed as they appear in the body of the report. The committee's other recommendations expand upon and support these key recommendations.

ring the NWS from the Department of Agriculture to the Department of Commerce in 1940 was to "permit better coordination of government activities relating to aviation" (NWS, 1970). At that time, the Civil Aviation Administration also was located within the Department of Commerce. The organizational proximity of federal weather and aviation agencies was subsequently lost when the NWS was subordinated to NOAA in 1970, and the Civil Aviation Administration evolved into the FAA and was transferred to the Department of Transportation. As a result of the current organizational arrangement, the NWS and FAA must exert a special effort to coordinate their aviation weather activities adequately on both a strategic planning basis and a day-to-day operational basis.

The 1977 memorandum of agreement sought to improve coordination between the FAA and NOAA by establishing high-level aviation weather liaisons. However, the position of NOAA Special Assistant for Aviation Affairs, which also reported to the FAA Administrator, was eliminated in 1978, and no position of comparable authority now exists within NOAA, the NWS, or the FAA. Since 1978, the FAA and NWS have worked together to procure several major aviation weather systems. Some of these procurements, such as ASOS, have experienced significant problems. One of the functions of the high-level FAA-NOAA liaisons established in the 1977 agreement was to clarify misunderstandings and increase the probability that new aviation weather systems and procedures developed by NOAA and the FAA would perform as expected in satisfying user needs.

Recommendation: *The FAA and NWS should reestablish the practice of assigning high-level liaisons who are formally tasked with defining and coordinating aviation weather requirements for research, development, and operations between the FAA and NOAA/NWS.*

Aviation weather is a specialized area that falls outside the mainstream of general-purpose weather services, and aviation forecasters require special skills and expertise to address the unique requirements of aviation. In order to reach their full potential, aviation forecasters should understand what meteorological information pilots, air traffic controllers, and other aviation weather users need in order to operate safely and efficiently. They should also understand the technology of their users almost as well as they do their own. They should then be able to tailor the weather services they provide to respond to their users' specialized needs.

Achieving this level of expertise requires that aviation meteorologists spend enough time with aviation weather users to develop a detailed understanding of—not just a general orientation to—their operational procedures, their operational tempo, their critical parameters, the scope of their missions, and the other sources of information—such as aircraft surveillance radars —that users must integrate with the meteorological information that forecasters provide. In fact, it is axiomatic in some aviation weather communities, particularly within the U.S. military, that aviation meteorologists must maintain close contact with the operational aviation commands that they support. Placing FAA and NOAA (i.e., NWS) offices in adjacent quarters at the same airport, as specified in the 1977 agreement, would have contributed to this goal. However, the committee saw no evidence of close contact between meteorologists and users at the airports it visited, in part because the FAA and NOAA offices were physically separated. For example, the aviation meteorologists at a Weather Forecast Office located at one major airport had never met with the tower or Terminal Radar Approach Control (TRACON) air traffic controllers who were one of their primary customers. The forecasters did occasionally speak with controllers by phone, but the forecasters acknowledged that they did not know the operational utility of the information they provided. In addition, when the committee itself met with the TRACON and tower controllers, it was told that forecasters sometimes reported information that was of limited value because, in the opinion of the controllers, the forecasters did not understand their needs.

The NWS Modernization Program will exacerbate this problem by moving many weather service offices away from local airports.[8] The FAA's consolidation of Flight Service Stations (FSSs) into new Automated Flight Service Stations (AFSSs), which are typically not collocated with NWS forecast offices, is also in conflict with the intent of the 1977 agreement to establish NOAA and FAA offices in adjacent quarters. In other words, it seems that neither the FAA nor the NWS still embraces the principle that placing FAA operational staff and aviation meteorologists at NWS forecast offices in a position to establish close working relationships is an important goal of the federal aviation weather program.

Committee members also detected a lack of interagency communication when it visited an FAA regional administrator and an NWS regional director who were located in the same federal office building and supervised regions that overlapped each other. These two officials

[8] The NWS Modernization Plan collocates new weather forecast offices with WSR-88D weather radar sites. The NWS favors locating these radars at sites that will optimize their performance. In general, this results in selecting sites that are not on the property of local airports. Also, property values often encourage the NWS to establish new offices at off-airport sites, which tend to cost less than airport property.

had never met or spoken on the phone, even though the NWS regional director was responsible for the provision of aviation weather services by dozens of aviation meteorologists assigned to his region.

Finding: *Routine meetings between FAA and NWS staff could be a valuable tool for improving (1) the practical understanding that aviation forecasters have regarding the needs of air traffic controllers, flight service specialists, and pilots for operational weather information; and (2) the understanding of air traffic controllers and flight service specialists regarding the capabilities, utility, and limitations of aviation weather information*.

Recommendation: *The FAA and NWS should encourage informal interagency meetings between small groups of staff members at all management levels who are involved in providing or using aviation weather information. In addition, the NWS should enable aviation forecasters to spend duty time routinely in the environments of the aviation weather users that they support*.

Effectiveness of Implementing Documents

Although federal legislation accepts responsibility for the provision of aviation weather services, relevant executive branch policy has been rescinded without replacement (as in the case of OMB Circular A-62), or it is ineffective because the FAA and NOAA do not comply with key elements of the policy (as in the case of the 1977 memorandum of agreement between the FAA and NOAA). Long delays in issuing new policy and noncompliance with existing policy indicate a lack of effective high-level agency leadership and attention within the FAA and NOAA regarding aviation weather services. This lack of effective high-level leadership means that mid-level managers must rely on their own resourcefulness and initiative to provide needed services.

Finding: *The manner in which the federal aviation weather system is managed fosters the development of de facto policies and procedures that limit overall system safety and efficiency*.

Recommendation: *The OMB, Department of Transportation, Department of Commerce, and other responsible federal agencies should expeditiously issue and implement updated or expanded policy directives to more fully comply with the intent of federal legislation regarding the provision of aviation weather services*.

FEDERAL AVIATION REGULATIONS

FARs (Federal Aviation Regulations), which are established by the FAA, govern the manufacturing, certification, inspection, and operation of aircraft registered in the United States. Many FARs deal specifically with weather. The following example illustrates the impact that weather-related FARs can have on aviation efficiency.

The FARs generally require U.S. carriers to designate an alternate airport (and carry enough fuel to get there with a specified margin) if the weather forecast specifies a ceiling below 2,000 feet or visibility of less than 3 miles during a time period of 1 hour before or after the expected arrival time at the primary destination (FAR sections 121.619 and 135.223). Australian air carriers, on the other hand, operate under Australian regulations, which require designating an alternate destination airport if the forecast for the primary destination includes a ceiling below 800 feet or visibility of less than 2 miles within 30 minutes before or after the flight arrival time. Also, Australian air carriers do not need to designate an alternate airport if the terminal forecast predicts that conditions of low visibility or ceiling will be temporary and arriving aircraft will have sufficient fuel to hold at the primary destination for at least 30 minutes. U.S. carriers do not have this option.

The difference in rules has a significant impact on the economic efficiency and competitiveness of U.S. carriers. For example, United Airlines and Quantas operate daily flights between Los Angeles and Sydney that depart within minutes of each other. United is required to comply with U.S. FARs, while Quantas operates in accordance with Australian regulations. Aircraft flying this route generally take off with a maximum load of passengers, freight, and fuel, and carrying extra fuel for an alternate destination is not always practical. In 1993, due to the differences in regulations concerning the use of alternate destination airports and the resulting fuel requirements, four United Airlines flights diverted to Brisbane or Nandi, while the matching Quantas flights flew directly into Sydney. Each of these diversions increased operational costs by a minimum of $30,000. In 1992, during one such diversion to Nandi, the United Airlines flight crew was unable to continue the flight to Sydney because of crew rest regulations. This diversion cost United Airlines $300,000 because it had to charter a Quantas aircraft for one leg of the return flight to fill in for the United Airlines aircraft that was delayed in Nandi.

FARs also reduce efficiency by sometimes requiring that flight plans include alternate airports, even if the forecast does not predict any weather conditions that would require diversion from the primary destination. For instance, minimum acceptable cloud ceiling for an instrument approach may be 200 feet at a particular airport, yet the FARs may require that flight plans specify an alternate destination unless the forecast ceiling is higher than 2,000 feet.

The state of the art of aircraft communications, navigation, air traffic control, and aviation weather systems has advanced a great deal since many FARs were last revised. In some cases, these advances may make it possible to relax some weather-related restrictions on aviation operations without degrading safety. As noted in the example above, Australia has operational experience with flight regulations that are less restrictive than those of the United States. It may be instructive for the FAA to formally assess the impact of such regulations on the safety and efficiency of Australian aviation in comparison to the safety and efficiency of U.S. aviation.

Recommendation: *The FAA should examine selected weather-related FARs and undertake rulemaking to incorporate appropriate modifications to enhance efficiency as well as safety*.

ESTABLISHING AN AIR TRAFFIC SERVICES CORPORATION

The FAA views the aviation weather services that it provides as a subset of air traffic services. Thus, the current legislative and executive branch framework that defines how aviation weather services and research are funded and provided would be altered if the federal government establishes a private or federal corporation to provide air traffic services. Given the continuing interest in proposals for establishing such a corporation, the committee examined the potential impact of creating an air traffic services corporation on the provision of federal aviation weather services and related research. The committee used the *Air Traffic Control Corporation Study* (DOT, 1994) as a basis for this examination because it is recent, it includes consideration of other related studies during the past several years, and its participants included senior officials within the Department of Transportation who will presumably play a key role in generating executive-branch proposals for restructuring the FAA. The study is summarized in the accompanying box.

The committee takes no position on the overall merit of establishing a private or federal corporation to take over some or all of the FAA's functions. However, if FAA responsibilities for day-to-day operations, system acquisition, research, regulation, and certification were to be split between a residual FAA and a new air traffic services corporation, it might become more difficult for a single organization or official to provide the kind of strong leadership that should be a key element of future efforts to improve aviation weather services and research.

The *Air Traffic Control Corporation Study* asserts that "a government [air traffic services] corporation can be structured to be financially self-sufficient" (i.e., it can operate without appropriated funds from the general treasury) and that "businesslike financial practices can reduce the financial burden on both users and the general taxpayer." The study goes on to recommend that such a corporation should establish user fees for commercial operators that would be offset by corresponding cuts in aviation taxes for these users. (General aviation and "public users" would permanently be exempted from paying user fees. although general aviation aircraft would remain subject to existing aviation fuel taxes.) If this funding scheme is implemented, then user fees paid by commercial air carriers would be the primary source of funds for the air traffic services corporation.

Establishing an air traffic services corporation, as described above, could have a negative impact on funding for basic research in aviation weather. Like the federal government, U.S. air carriers are under severe financial pressure, and they are likely to resist increasing their financial contributions to the provision of air traffic services. Because basic research is farther removed from operational systems than applied research and technology development, it is often the first area to be cut when operational agencies face budgetary constraints. Aviation weather research already faces this situation within the

THE AIR TRAFFIC CONTROL CORPORATION STUDY

Many studies have examined whether to alter the basic structure of the FAA. One of the most recent studies began in 1993 when the Secretary of Transportation established an ad hoc committee to study the benefits of organizationally restructuring the air traffic control system. This committee consisted of employees of federal agencies and government corporations, including Department of Transportation assistant secretaries, the FAA Administrator, and other high-level government officials. The resulting report, the *Air Traffic Control Corporation Study* (DOT, 1994), included a renew of 13 other study reports produced since 1985 that have examined the operation of the FAA. Seven of the 13, including the report produced by Vice President Gore's National Performance Review, recommended establishing a government corporation to provide some or all of the services currently provided by the FAA. The *Air Traffic Control Corporation Study* concurs with this approach by recommending the formation of a not-for-profit U.S. government corporation, the U.S. Air Traffic Services Corporation, to "operate, maintain, and modernize" the air traffic control system.

FAA and NOAA and, as research funding has decreased over the last few years, aviation weather research laboratories have had to tie themselves more closely to development programs for operational systems. Historically, basic research is the foundation upon which future development programs are based, and reductions in basic research tend to degrade the ability to develop new operational systems.

The *Air Traffic Control Corporation Study* reinforces the perception that the FAA does not adequately recognize the importance of weather to aviation safety and efficiency. For example, the 200-page report does not address weather-related issues associated with restructuring the FAA. In particular, the chapter on aviation safety discusses system capacity; separation of aircraft from each other; regulatory practices; and aircraft manufacturing, certification, and maintenance; however, it does not address aviation weather services. Establishing an air traffic services corporation is not necessarily inconsistent with the committee's recommendation for improving aviation weather services. However, it is important to consider aviation weather services and research as corporatization proposals are being structured and evaluated, rather than as they are being implemented.

Recommendation: *The FAA should assess how proposals to establish a private or federal air traffic services corporation would impact aviation weather services and related research*.

This report contains many recommendations for the FAA to improve aviation weather services and research. In general, implementation of these recommendations can proceed in parallel with the process of deciding whether to establish an air traffic services corporation. For example, as elaborated upon in Chapter 6, this report recommends that the FAA exert strong leadership in the planning and providing of aviation weather services. Implementation of this recommendation should be initiated immediately, even if the government anticipates establishing a federal or private air traffic services corporation. Enabling legislation for a new corporation, if one is established, should support this recommendation by focusing responsibility for aviation weather within one organization (i.e., either the new corporation or the residual FAA) and by clearly defining how the new corporation and the residual FAA would provide aviation weather services and conduct related research.

Recommendation: *The FAA should expeditiously improve aviation weather services rather than delay action while the federal government decides whether to establish an air traffic services corporation to provide some or all of the functions currently provided by the FAA*.

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3

Current Services

The aviation weather system is not as effective as it could be. Aviation weather services that provide accurate and timely information about operationally significant weather are needed for effective decision making by pilots, controllers, and other users. The FAA and NWS should respond to urgent unmet user needs related to weather observation, analysis, forecasting, dissemination, and training.

One way to assess the near-term effectiveness of aviation weather services is to examine whether they meet user needs for accurate and timely information about operationally significant weather. This approach is consistent with the approach that the FAA itself is using to plan improvements in the aviation weather system. As noted in FAA Order 7032.15, "In the past, weather needs were based on the capabilities of proven technology. Today, because of the explosive pace of emerging technologies, a shift toward defining a weather system in terms of user operational needs is essential to allow the operational systems planning process to make the best use of technologies" (FAA, 1994b).

This chapter assesses the effectiveness of (1) currently available aviation weather services and (2) training programs for providers and users of aviation weather services. Based on these assessments, this chapter then identifies unmet user needs that should be addressed by improving existing systems and by developing new systems, as appropriate.

AVIATION WEATHER SERVICES

Within the United States, aviation weather services are provided to nonmilitary aircraft primarily by the FAA, the NWS, and the private sector. The Department of Defense (DoD) contributes to the national effort by sharing weather data produced under its auspices and by providing tailored weather services for military operations.

As shown in Figure 3–1, the process by which aviation weather services are provided can be divided into four phases:

- observation;
- analysis;
- forecasting; and
- dissemination.

All four phases must operate effectively for the overall aviation weather system to meet user needs; lapses anywhere along the chain jeopardize the outcome.

Observation

Comprehensive, up-to-date meteorological observations are necessary to meet the needs of the general public for accurate and timely reports of current and forecast weather conditions. Traditionally, the essential data needed to meet aviation weather needs were provided by hourly surface observations made by human weather observers stationed at airports, twice-daily upper-air observations made with the aid of inflatable weather balloons (i.e., rawinsondes), and unscheduled reports from pilots in flight. These basic observations are now augmented with a wide array of additional observational data from weather radars, visible and infrared satellite-imaging systems, automated aircraft reporting systems that collect upper-air wind and temperature data from en route aircraft, automatic wind profilers that use ground-based radars to measure upper-air winds, and automated surface weather observation systems. Data from these new systems have significantly enhanced the national meteorological database.

The NWS and U.S. Air Force collect or transmit most of the meteorological data used in the United States to operate national and global weather models. For example, each weekday the NWS receives more than 50,000 surface observations, over 4,000 upper-air observations, and approximately 8,000 automated aircraft reports. The

NWS receives additional inputs from weather radars, weather satellites, ships, ocean buoys, and other domestic and international sources. About 240 surface observation sites are staffed by NWS employees. Surface observations are made at over 1,000 additional sites by NWS contractors and automated systems, the FAA, DoD, other federal agencies, state governments, air carriers, and other private organizations.

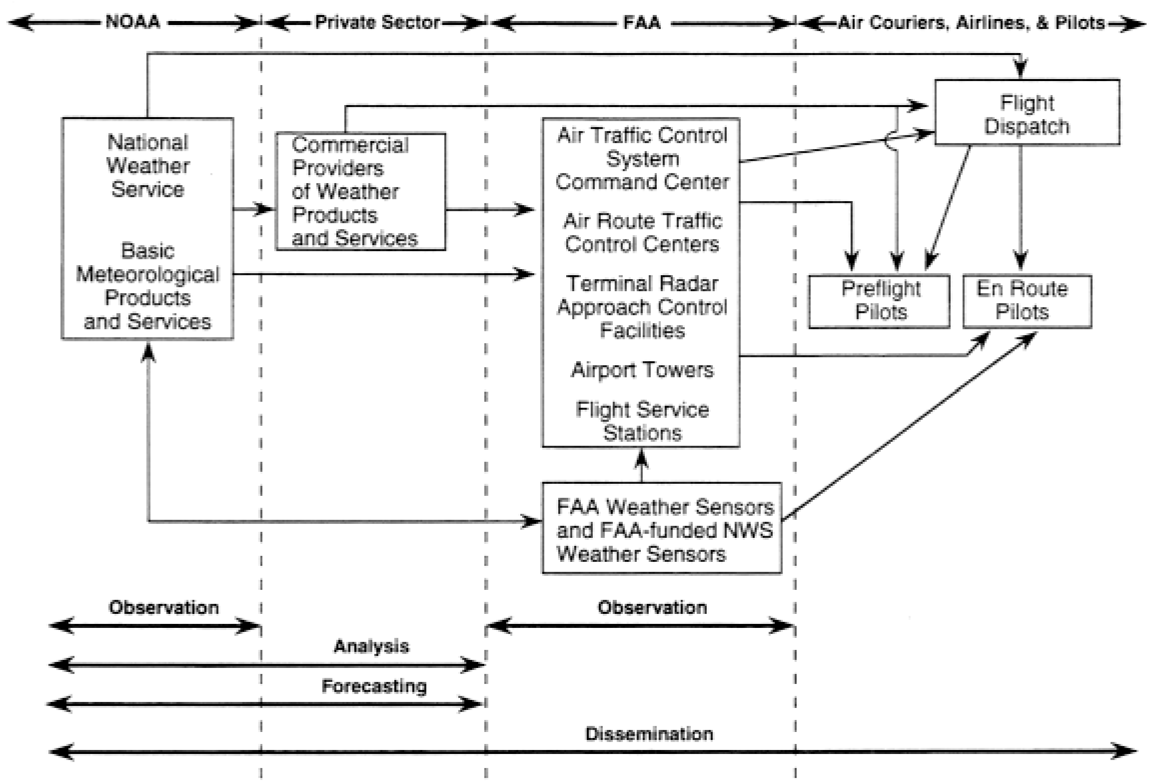

Figure 3-1
National Aviation Weather System. (Source: FAA, 1994a)

The FAA also supports the collection of meteorological data to meet the special needs of the aviation community. The FAA has developed—on its own or in cooperation with NOAA and/or the DoD—the following weather observing systems:

- Automated Weather Observing System (AWOS)—developed by the FAA;
- ASOS (Automated Surface Observing System)—developed by NOAA and the FAA;
- TDWR (Terminal Doppler Weather Radar)—developed by the FAA;
- Low Level Windshear Alert System—developed by the FAA;
- WSR-88D weather radars—developed by NOAA, the FAA, and DoD;[1]
- airport surveillance radars with weather capability—developed by the FAA;[2] and
- automated aircraft reporting of weather conditions—developed by the FAA and NOAA.

The FAA also collects pilot reports about weather information. The FAA reports observational data that it collects from all of these sources to the NWS.

The committee identified three areas of particular concern related to the ability of aviation weather services to meet user needs for aviation weather observations:

- number and location of weather observing sites;
- pilot reports and automated aircraft weather observations; and
- automation of surface observations.

[1] The WSR-88D weather radar is also commonly referred to as NEXRAD, the NEXt Generation Weather RADar.
[2] In areas that do not yet have weather radar coverage, the NWS extracts weather information from air waffle control radars operated by the FAA.

In addition, as discussed in Chapter 4 (pages 44 and 45), the committee also is concerned about the need for new sources of meteorological data, especially atmospheric humidity, icing, and turbulence.

Number and Location of Weather Observing Sites

Aviation in many parts of the United States is adversely impacted by the limited availability of weather observations. Although weather radar and satellite observations can provide useful information in data-sparse regions, such observations do not include parameters such as visibility, surface winds, and atmospheric pressure that are important to aviation users. Thus, surface weather observations remain an important source of meteorological data for aviation.

In some cases airports have instrument approaches, but pilots cannot operate under instrument flight rules without official weather observations. This situation will become more common as changes in the air traffic system allow more pilots to use navigation signals from the Global Positioning System to conduct instrument approaches at small airports that currently lack this capability.

The availability of weather observations is also an issue in remote regions of Alaska and in mountainous portions of the west (see Chapter 5, page 48). Mountainous terrain increases the need for weather observing sites for several reasons:

- Mountain ridges limit the horizon of weather observers; the far side of the ridge becomes an area of meteorological uncertainty.
- Mountains often create small-scale weather phenomena that may not be detected by existing weather observing systems or forecast by available weather forecasting techniques.
- Mountainous terrain may restrict the movement of small aircraft, limiting their ability to avoid or escape from unexpected adverse weather that they may encounter.

Currently, there are few affordable options for significantly increasing the number of weather observing sites in remote or mountainous regions. Automated weather observing systems require electrical power, communications, and periodic maintenance that can be quite difficult to provide in remote or mountainous regions where observations are most needed. Likewise, establishing and maintaining a weather observing site staffed by NWS-certified weather observers is often not an affordable option, in part because current standards require certified weather observers to accurately classify a wide range of weather phenomena.

One way to foster the proliferation of official nonfederal (i.e., state, industry, or site-specific volunteer) weather observing sites would be to establish one or more classifications of weather observers, who would be trained and certified to provide partial weather observations. These observers would be able to provide essential information, such as cloud ceiling, visibility, temperature, barometric pressure, runway condition (at airport locations), and precipitation. In many areas, local pilots currently plan their flights by calling personal contacts along their flight path and at their destination to obtain this type of information unofficially. Training and certifying sources of partial weather observations would increase the accuracy of these observations and improve the dissemination of information by making it possible to process these observations as "official" weather observations.

The Alaska Airmen's Association recently initiated a similar effort by encouraging pilots to make pilot reports of adverse weather conditions in remote regions even if they are on the ground and not engaged in flight-related activities. (The Airmen's Association suggests making these "pilot reports" via telephone to the AFSS [Automated Flight Service Station] in Alaska that receives such reports from pilots in flight.) The FAA already encounter pilots to report weather conditions that they encounter in flight, and these observations are processed and disseminated by the FAA and NWS even though pilots generally are not trained or certified as official weather observers and may have very limited meteorological training.

Recommendation: *The NWS should foster the proliferation of official non-federal weather observing sites by establishing one or more additional classifications of surface weather observers, who would be trained and certified to provide partial weather observations.*

Pilot Reports and Automated Aircraft Weather Observations

Pilot reports are an excellent source of localized, altitude-specific observations of weather conditions such as icing, turbulence, and cloud type that are important to aviation and that may be hard to obtain otherwise. Nonetheless, as-emphasized by *Weather for Those Who Fly* (NRC, 1994), pilot reports have long been an underused resource. Such reports are aperiodic, labor intensive, cumbersome, and often unformatted. Pilots must make a verbal report to an air traffic controller who may be too busy controlling traffic to deal with weather reports, or they must change radio frequencies to contact a FSS (Flight Service Station) or AFSS. Once pilot reports have been received by an air traffic controller or flight service specialist, he or she must write down the information and then pass it along so it can be processed. As a result, many pilot reports never make it into the aviation weather data collection system. Pilots, controllers, and flight service specialists need encouragement to generate and disseminate pilot reports. In addition, processing and dissemination systems should make it easier for users to sort through and obtain useful information from pilot reports quickly.

Several air carriers use the Meteorological Data Collection and Reporting System (MDCRS) to provide the NWS with automated aircraft observations. MDCRS receives information on upper-air winds and temperature from specially equipped commercial aircraft and translates it into a standard format for use by the NWS. The FAA funds the operation of MDCRS, but air carriers must pay for the cost of automated meteorological sensors for their aircraft and for air-to-ground transmission of data.[3] Airlines receive no financial compensation from either the FAA or the NWS for providing MDCRS observations. The fact that air carriers continue to provide MDCRS data indicates that the benefits they receive exceed the additional costs involved. Nonetheless, individual air carriers are paying to generate meteorological data that are of general benefit to the aviation community and national forecasting capabilities.

Automated aircraft reporting significantly increases the availability of in flight meteorological data. United Airlines recently shifted to the use of automated reporting in lieu of pilot reports for routine reports of position, wind, and temperature. As a result, it started receiving approximately 8,000 reports per day instead of 200–300 reports per day.

The *U.S. Weather Research Program Implementation Plan* recommends substantially increasing the number of aircraft equipped to collect MDCRS data and expanding the MDCRS effort to include humidity data.[4] Currently, the FAA is sponsoring the development of humidity and turbulence sensors for use with MDCRS. However, despite the current value and future promise of automated aircraft reporting, neither the FAA nor the NWS has definitive plans to expand MDCRS or to establish it permanently as an operational weather observing system.

Recommendation: *The FAA should ensure that long-term operational funding is provided for MDCRS. In addition, the FAA should enhance the value of MDCRS by encouraging more air carriers to participate in the program.*

Automation of Surface Observations

Surface observations generally include detailed information about atmospheric conditions at a particular site, including temperature, barometric pressure, dew-point temperature, altimeter setting, visibility, clouds, precipitation, and wind speed and direction. Both the NWS and the FAA are increasingly relying on new technologies to replace labor-intensive manual weather observations with automated observing systems. Many automated surface observing systems are being located at or near airports. The proper operation of these units is important to meet the needs of aviation.

The FAA initiated acquisition of automated surface observing systems in 1988 when it issued a contract to acquire 160 AWOS units for deployment at airports that had no certified weather observers. Although AWOS was not intended to duplicate all of the functions that a human weather observer provides, it does provide certified weather data such as ceiling, visibility, wind speed and direction, and altimeter settings.

State governments have also procured about 275 AWOS units. Most of these units are connected to the national data collection system, but states have sometimes had a difficult time connecting to the system. In some cases, changes in technical specifications associated with the federal system created incompatibilities with state systems, and states have sometimes balked at paying to modify their systems to accommodate these changes. The availability of weather observations from state AWOS units that are not connected to the federal system is limited to individual state-operated weather dissemination systems.

In 1991 the NWS, with FAA support, issued a contract to acquire ASOS. ASOS is an improved weather observing system that is the centerpiece of the NWS plan to replace human weather observers with automated systems as part of the NWS Modernization Program. The NWS, FAA, and DoD intend to install a total of 868 ASOS units by fiscal year 1997 at a cost of $351 million (GAO, 1995b). Table 3-1 depicts the status of this process as of December 2, 1994.

Like AWOS, ASOS can be a valuable source of weather observations. ASOS units provide a continuous weather watch and enable instrument flight operations at airports where human weather observers are not assigned or are on duty less than 24 hours per day. For example, ASOS provides arriving pilots with up-to-date altimeter settings that are valuable to all pilots and are essential for instrument landings (at night and during inclement weather). In addition, tower controllers at airports with

[3] Data are transmitted from aircraft to the ground via the Aeronautical Radio, Inc. (ARINC), Communications Addressing and Reporting System (better known as ACARS), which is owned and operated by ARINC on behalf of U.S. commercial air carriers. MDCRS Collects data that ACARS has already collected on the ground.

[4] The U.S. Weather Research Program is an interagency effort that includes the Department of Transportation, Department of Commerce, DoD, NASA, and the National Science Foundation.

out NWS weather observers will benefit from ASOS because it will relieve them of their current responsibility for making weather observations and will allow them to focus on controlling aircraft. Automated systems also offer the potential of consistent and reliable weather observations that are not affected by human variability in making weather observations.

TABLE 3-1 Status of Commissioning ASOS Units (Source: GAO, 1995b)

	Units Purchased	Units Delivered	Units Commissioned
NWS	232	159	45
FAA	352	312	2
DoD/Navy	33	20	Not Applicable[a]

[a] NWS commissioning procedures do not apply to Navy ASOS units.

Implementation of the ASOS system has involved some problems. In particular, many aviation users believe that replacing full-time human weather observers with ASOS units, as they are currently designed, produces a degradation in service to the aviation community. Appendix E (page 82) discusses the following specific issues associated with ASOS system performance:

- availability of the data communications system;
- interpretation of ASOS readings;
- instrument performance and system development testing;
- completeness of the weather observation;
- equal or better level of service;
- augmentation of ASOS observations;
- access to ASOS data;
- authority of controllers to override ASOS readings;
- maintenance and backup; and
- site selection.

Concerns about ASOS are not new. In 1991 the National Research Council determined that "although ASOS offers some clear advantages over the present surface observation method in operational weather forecasting and warning, serious concerns exist about its accuracy, representativeness, and system performance" (NRC, 1991).

ASOS system performance is also the subject of a recent report by the General Accounting Office (GAO) (GAO, 1995b). The GAO concluded that "ASOS is performing neither as intended or expected.... While ASOS meets many of its specified requirements ... six of eight sensors in the ASOS system do not meet key contract specifications for accuracy or performance." The GAO also determined that ASOS "does not provide certain capabilities that some users say are critical to ensuring safe aviation.... While the NWS has corrective actions under way, it has determined neither the full range of problems that it will address nor how much the system enhancements or supplements needed to do so will cost.... ASOS problems in meeting both specified requirements and user needs [that go beyond the scope of existing ASOS system specifications] ... have yet to be resolved." Although the NWS did not concur with many of these conclusions (DOC, 1995), the GAO report does illustrate the type of criticism that ASOS continues to attract from some aviation users.

The committee did not conduct a detailed assessment of issues associated with the automation of aviation weather services such as those described above for ASOS. However, in the opinion of the committee, lessons learned from the ASOS acquisition experience include the following:

- Users should be fully involved in the acquisition of new systems that will impact the aviation weather services upon which they depend. The NWS relies on the FAA to define aviation user requirements for meteorological systems. As a result, the FAA should ensure that it accurately assesses the needs of all segments of the aviation community and translates those needs into system requirements.
- The best time to build user acceptance is while systems are being developed. This becomes much harder and more costly after systems have been fielded, especially if user confidence is shaken by a negative first impression.
- System acquisition managers should fully develop strategies and implementation plans with other relevant offices and agencies to ensure that the deployment of new systems accommodates related system interfaces, agency staffing, logistical support, regulatory requirements, and training for agency staff and other system users.
- Extended field testing in an operational environment should be performed to ensure that systems with cutting edge technology are ready to enter service.
- Whenever practical, installation should include an overlap period during which data are collected from both existing and new sensors. This would give users an opportunity to become more aware of characteristic differences in the two data sets. (It would also make the data somewhat more useful in tracking climatic change.)

Senior officials within both the FAA and the NWS seem to recognize that their involvement will be necessary to ensure that systems developed in the future benefit from the ASOS experience. In addition, despite the difficulties encountered with ASOS, the committee remains confident that automation of aviation weather services offers the potential to reduce costs and increase quality.

Recommendation: *The FAA and NWS should continue to resolve user-identified issues associated with ASOS and use the lessons learned from the ASOS acquisition to improve the process by which new systems are conceived, developed, and deployed.*

Analysis

Analysis is the critical link between weather observations and forecasts. Analysis produces an integrated description of the atmosphere that is consistent with observed data. This description takes the form of data sets and graphics that describe and depict the geographic distribution of weather parameters such as temperature, pressure, radar reflectivity, cloud cover, and wind. These data sets also define the initial conditions needed to generate numerical weather forecasts.

Within the aviation weather community, data analysis focuses on the aviation impact variables—such as ceiling, visibility, turbulence, and icing—that are particularly important to flight operations. In some cases private weather services that market customized services use observational data sets and analysis products produced by the NWS as the foundation for generating their own analysis products. However, the vast majority of analysis products are produced directly by the NWS.

The committee identified one area of particular concern related to the ability of aviation weather services to meet user needs for analysis of meteorological data: new automated observing systems are greatly increasing the quantity of meteorological data that must be analyzed. To accommodate this increase, the NWS is improving its information processing capabilities. In addition, the FAA is funding the NOAA Forecast Systems Laboratory to develop the Aviation Gridded Forecast System. This system will analyze observational data to create a three-dimensional gridded data set of observed, calculated, and short-term forecast weather data that impact aviation. The gridded data set will serve as a common source of data for aviation forecasters at the NWS and elsewhere. As a result, the Aviation Gridded Forecast System offers the potential to increase the level of consistency and compatibility among a wide variety of aviation weather products.

Recommendation: *The FAA and NOAA should maximize the payoff of national investments in new weather observing systems by implementing improved information processing systems and new data analysis tools such as the Aviation Gridded Forecast System.*

Forecasting

Forecasting uses observed and analyzed weather data to produce weather forecasts that project the current state of the atmosphere into the future. The NWS's National Centers for Environmental Prediction (formerly the National Meteorological Center) in Suitland, Maryland, operates a variety of national and global numerical models to produce national, global, and oceanic analyses and forecasts. These analyses and forecasts, together with information from other sources, serve as a basis for more specialized forecast products, including both generalized weather forecasts and products aimed at specific users, such as terminal, en route, and oceanic forecasts for aviation.

Terminal forecasts cover geographic regions in the vicinity of an airport and provide information that pilots need for take off and landing. En route forecasts cover flight paths between the point of departure and destination. Oceanic forecasts (for aviation) describe weather conditions for long distance flights over ocean areas.

Aviation weather forecasting has much in common with other types of forecasting, such as severe storm forecasting. In fact, the NWS's National Aviation Weather Advisory Unit is an element of the National Severe Storms Forecast Center. Nonetheless, aviation weather forecasting has different concerns than general forecasting. For example, extended rainfall may have only a moderate impact on aviation, while associated flooding could seriously impact the general public. A long line of thunderstorms, on the other hand, may interrupt flight operations in a wide region, even though it may not have significant impact on the general public.

Accurate forecasts are necessary for efficient planning of flight operations. Terminal forecasts are particularly important because most weather-related accidents and delays are associated with adverse weather in terminal areas. NWS aviation forecasters in local weather offices produce terminal forecasts for designated airports in their areas of responsibility. This responsibility is being assigned to the 118 Weather Forecast Offices that the NWS is establishing as part of the NWS Modernization Program.

In addition, the FAA funds the NWS to provide dedicated support to aviation by operating the following aviation weather facilities:

- The National Aviation Weather Advisory Unit in Kansas City, Missouri. This unit generates short-term (6-to 12-hour) regional aviation forecasts and hazardous aviation weather advisories for the 48 contiguous states. (The NWS regional offices in Honolulu and Anchorage provide these services for Hawaii and Alaska, respectively.)

- The Central Flow Weather Service Unit at the FAA's Air Traffic Control System Command Center in Reston, Virginia. NWS meteorologists at this unit produce tailored forecasts to support day-to-day strategic planning of aviation within the United States and along oceanic routes leading to and from the United States.
- A Center Weather Service Unit (CWSU) at each of the FAA's 21 Air Route Traffic Control Centers (ARTCCs). The ARTCCs are responsible for en route flight operations within the United States. Each CWSU prepares tailored forecasts for the air traffic control supervisors and air traffic managers at the corresponding ARTCC.[5]

Each of these facilities uses a mixture of individual weather products that they obtain from either the NWS or private weather services. The private weather services, in turn, access data and information (for a fee) from the NWS and other sources for repackaging and resale to public and private users. New resources such as the Aviation Gridded Forecast System database should increase the access of private vendors to NWS analysis and forecast products and significantly improve the quality of aviation weather products that are developed by both the NWS and the private sector.[6]

The committee identified four areas of particular concern related to the ability of aviation weather services to meet user needs for aviation weather forecasts:

- use of forecasts prepared by private weather services;
- short-term forecasts/nowcasts;
- geographic resolution of weather forecasts; and
- feedback from users to aviation weather forecasters.

Use of Forecasts Prepared by Private Weather Services

The FAA separately approves the process that each air carrier uses to obtain required meteorological information. As a result, even though the FAA may approve the use of a particular set of weather products by one air carrier, other air carriers cannot use them as an essential element of their meteorological process unless the FAA grants them specific permission to do so. This policy complicates the process that air carriers must use to adopt new and improved weather products that private weather services make available.

FARs (Federal Aviation Regulations) require that pilots of all types use weather information from "approved sources." In many cases pilots and dispatchers obtain some of their weather information from private weather services, television weather programs, and newspapers. However, neither the FAA nor the NWS certify weather products provided by such sources. In fact, there is no mechanism for private weather services to be designated as an "approved source" of weather information for general or business aviation pilots, even though many of these pilots routinely rely on private weather services for preflight weather information.

One of the reasons that the NWS declines to certify any private weather services as an approved source of meteorological information for aviation is its concern that it might be held liable if an NWS-approved private weather service produced an inaccurate weather product that contributed to an aircraft accident. However, the committee notes that the FAA licenses pilots and regulates the manufacture and maintenance of aircraft, yet the FAA assumes no liability if licensed or certified pilots, aircraft manufacturers, parts suppliers, or mechanics make an error in judgment or provide a defective product that results in an aircraft accident. Thus, it should also be feasible to license qualified private weather services.

Recommendation: *The FAA and NWS should develop a procedure to designate private weather services as approved sources of specific aviation weather products.*

Short-Term Forecasts/Nowcasts

Most domestic flights last less than 5 hours. Therefore, short-term forecasts that cover the next 6 hours or so are of particular interest to aviation. In addition, airport "nowcasts," which cover the next 30–60 minutes, are especially important to allow air traffic controllers and pilots to coordinate the position of arriving aircraft to accommodate short-term weather phenomena such as thunderstorms and windshear. The NWS recently conducted a study of terminal forecasts that concluded that the accuracy of forecast ceiling and visibility at 90 airports in the United States did not seem to have improved between 1983 and 1994. That study also concluded that the 3-hour forecasts of ceiling and visibility that are contained in terminal forecasts are generally less accurate than 3-hour "persistence forecasts." In other words, based on that study, assuming that observed ceiling and visibility will remain unchanged for the next 3 hours is more accurate, on average, than NWS terminal forecasts of ceiling and visibility (Dallavalle and Dagostaro, 1995).

[5] Air traffic controllers maintain tactical control of designated aircraft to prevent aircraft collisions. Air traffic managers at the national Air Traffic Control System Command Center and the 21 regional ARTCCs regulate overall traffic flow to avoid overloading individual airports by allowing too many incoming aircraft to arrive at one time, especially in cases of adverse or deteriorating weather conditions.

[6] Chapter 6 (pages 57 and 58) addresses the balance between services provided by the NWS and private weather services.

Recommendation: *The NWS should continue ongoing efforts to increase the availability and accuracy of short-term forecasts and nowcasts.*

Geographic Resolution of Weather Forecasts

During cold weather, current forecasting methods may conclude that potential icing conditions exist over hundreds of thousands of square miles of U.S. airspace. Icing, however, is usually a localized phenomena. A recent comparison of icing forecasts with pilot reports of icing determined that 70–80 percent of icing forecasts may be false alarms. In addition, even though current methods predict that icing hazards exist over very large geographic areas, this comparison determined that, for the data set examined, about 20–30 percent of icing events reported by pilots were not predicted by current forecast methods (Brown et al, 1995).[7] As a result, current forecasting methods are usually not a useful tool for determining whether an individual pilot on a specific flight will actually encounter icing. Current methods also have limited abilities to produce localized predictions of other weather phenomena, such as turbulence, thunderstorms, and windshear, that are of particular interest to aviation. Improved forecasting methods would increase the ability of pilots and dispatchers to avoid these hazards by modifying their flight plans.

Recommendation: *The NWS should continue ongoing efforts to increase the accuracy, timeliness, and geographic resolution of en route and terminal forecasts, especially with regard to icing and turbulence.*

Feedback from Users to Aviation Weather Forecasters

NWS Weather Forecast Offices may issue two or three forecasts daily for a dozen or more airports. However, in contrast to the meteorological organizations of military services and commercial air careers, Weather Forecast Offices receive little or no feedback from pilots or other users regarding the accuracy, impact, or overall utility of their forecasts. Accurate feedback is important to assess and improve forecasting skills and methods.

Recommendation: *The FAA and NWS should develop a process to allow pilots and other users of airport terminal forecasts to provide timely feedback to the NWS forecasters who generate these forecasts.*

Dissemination

Dissemination involves the delivery of aviation weather information to a wide variety of users. This information may consist of raw observational data, analyzed data, or forecast information. In most cases, the information is packaged in the form of a standardized audio, alphanumeric, or graphic weather product that is familiar to intended users. (Alphanumeric weather products, however, typically use coded abbreviations that are difficult for many users to interpret efficiently.) Depending upon the situation, weather information may be transmitted from person to person using telephone, radio, or face-to-face conversation; by a recorded or computer-generated telephone or voice message; by computer modem; or by other modern forms of telecommunications.

Preflight weather information enables pilots to plan for expected weather along their routes of flight. En route weather information enables them to monitor changing weather conditions and adjust their flight plans as necessary. To illustrate this process, Appendix F (page 86) contains descriptive scenarios of two sample general aviation flights.[8] Both scenarios are taken from FAA Order 7032.15 (FAA, 1994b). The first example is based on the air traffic control system as it existed in 1994 and identifies the following operational shortcomings:

- General aviation pilots who rely on the FAA for their preflight and en route weather may receive information that is "incomplete, inconsistent, and outdated."
- Radar information is "often too old to be useful by itself."
- Flight service specialists (1) spend too much time interpreting alphanumeric data, (2) may be "unable to relay accurate information on thunderstorm cells and the exact location of potential icing and turbulence," and (3) may be unable to disseminate pilot reports of adverse weather conditions "at their time of receipt because of equipment limitations" and workload constraints.
- The exchange of weather information between pilots and air traffic controllers "was time-consuming, work-intensive, and caused [radio] frequency congestion that affected airspace capacity and ATC [air traffic control] efficiency."

The committee concurs with this assessment.

[7] This study compared archived data from pilot reports with icing conditions predicted by several different forecast models. Results varied widely from model to model and as a function of altitude. On average, however, only 20–30 percent of icing forecasts were verified by pilot reports. Lack of consistency between forecast conditions and reported conditions is caused by model inaccuracies and by the fact that pilot reports do not constitute a comprehensive and error-free record of meteorological conditions. Some occurrences of adverse weather are not reported by pilots, and some pilot reports are not fried and retained in official records.

[8] Similar scenarios are also included in *Weather for Those Who Fly* (NRC, 1994).

The second scenario described in Appendix F describes what it might be like for a general aviation pilot in the year 2015. As reported in Appendix F and other FAA documentation, the FAA anticipates that changes in the federal aviation weather system will increase the efficiency of providing aviation weather services, improve flight safety, and increase airspace capacity. To accomplish these goals, the FAA plans to improve its communications and display systems and rely more on automated systems to observe the weather and generate forecasts, warnings, and other weather products that are tailored to meet the specific needs of pilots, controllers, and other aviation users (FAA, 1994a; FAA, 1994b). The committee agrees that the improvements illustrated in the 2015 scenario are worthwhile, and it believes that the federal government should be able to implement most of them in significantly less than 20 years.

The committee identified six areas of particular concern related to the ability of aviation weather services to meet user needs for dissemination of aviation weather information:

- federal efforts to reduce dissemination costs;
- form and content of weather products;
- dissemination to pilots en route;
- role of air traffic controllers;
- effectiveness of Center Weather Service Units; and
- dissemination to airport operators.

Federal Efforts to Reduce Dissemination Costs

The FAA disseminates preflight weather information to individual pilots using FSSs (Flight Service Stations), AFSSs (Automated Flight Service Stations), and the Direct User Access Terminal Service (DUATS). Like much of the federal government, the FAA is under increasing pressure to cut costs (See Appendix G, page 90). The FAA views dissemination of preflight and en route weather information as one area where it may be able to reduce expenses. However, the effort to reduce costs should be carefully managed to ensure that users have continued access to quality aviation weather services.

The FAA has nearly completed the process of consolidating and modernizing its flight service network, which consisted of 317 FSSs in 1981, into a more compact network of 61 AFSSs and 31 part-time or seasonal FSSs, which will provide supplemental service in "locations of unique weather or operational conditions" such as Alaska (FAA, 1995a). This consolidation is reducing the cost of providing flight services, but neither the user community nor the FAA seems to be satisfied with the outcome of the ongoing consolidation.

Most users of AFSSs and FSSs are pilots of general aviation, business aviation, and small commuter aircraft. Prior to shutting down the old FSSs, the FAA made a commitment to these users that the process of consolidating and automating FSSs would result in an equal or better level of service. In fact, based on their experience with the consolidated network, many users view the new system as an improvement. However, many other users believe that the FAA needs to improve the quality of services that AFSSs provide in order to meet its commitment to equal or better service. These users often point to the impact of losing local weather briefers who are knowledgeable about local weather conditions. In addition, even though the FAA has invested hundreds of millions of dollars in this modernization and consolidation effort, some users question the utility of the new weather briefing systems that have been installed. They also have ongoing concerns about the effectiveness of the next generation of AFSS weather briefing systems (i.e., the Operational and Supportability Implementation System, which is better known by its acronym, OASIS) that the FAA intends to procure during the next few years.[9]

Within the FAA, which originally proposed consolidating all 317 FSSs into just 3 facilities, aviation weather managers interviewed by the committee continue to question the need for government-provided flight services, and a recent FAA-sponsored assessment of flight services concluded that functions such as preflight weather briefings and flight planning that are now provided by FSSs and AFSSs could "readily be assumed by soon-to-be-available technology" (Banks, 1995). However, a more-comprehensive FAA-sponsored study concluded that FSSs and AFSSs should continue as the primary means of disseminating preflight information for the foreseeable future (FAA, 1994d).

DUATS, which became operational in February 1990, provides pilots with an alternate source of preflight weather information (besides FSSs and AFSSs). The FAA only authorizes active pilots (i.e., those with a current license and medical certificate) to access DUATS. The purpose of this policy is to limit DUATS use to those pilots who really need it (i.e., those who are fully certified to fly).

DUATS is provided by two commercial vendors under contract to the FAA. The vendors are reimbursed on a per-use basis by the FAA, so the vendors compete with each other to attract users. DUATS is used by civil

[9] The committee is not aware of any scientific surveys of aviation weather users. User opinions described here and elsewhere in the report are based on the personal experience of committee members, views expressed at public meetings related to aviation weather, and informal surveys conducted by the Aircraft Owners and Pilots Association and the Alaska Aviation Safety Foundation.

ian pilots of all types, although most users are general aviation pilots.

DUATS allows pilots to carry a record of current meteorological data with them in flight. However, it provides no opportunity for human interaction. Also, as illustrated in *Weather for Those Who Fly* (NRC, 1994), standard DUATS weather briefings contain no graphic weather information. Instead, pilots normally receive pages of coded data that they must interpret to build their own picture of the weather. This can be a difficult task, and many pilots prefer to call a weather briefer at an FSS or AFSS instead of, or in addition to, obtaining weather information from DUATS.[10]

The FAA charges no user fees for either DUATS or FSS/AFSS services. In order to reduce its costs, the FAA eliminated funding for DUATS in its proposed budget for fiscal year 1994, but funding was restored by Congress. During fiscal year 1993, DUATS services cost the FAA about $10 million, or $1.67 per call. By comparison, the preflight services provided by FSSs and AFSSs cost the FAA about $220 million during fiscal year 1993, or $5.00–$9.00 per call (Thomas, 1995; GAO, 1994; FAA, 1994d).[11] This cost differential indicates that DUATS can produce cost savings if it reduces the need for pilots to contact FSSs and AFSSs.

DUATS-like services also could reduce dissemination costs by improving the ability of FSSs and AFSSs to disseminate weather information efficiently. For example, weather briefings would probably take less time if both pilots and flight service specialists could view some of the same weather products. This could be accomplished if a new DUATS-like service and improvements to the weather information systems installed in AFSSs allowed flight service specialists to access pilots' DUATS weather briefings and discuss any questions pilots may have. This also could be accomplished if the FAA disseminated some of the graphic weather products and decision aids used by flight service specialists to pilots via telefax or as part of an improved DUATS-like service. (See Scenario Two in Appendix F, page 88.)

Recommendation: *The FAA should implement an improved DUATS that (1) makes it easier for pilots to understand what weather conditions are likely to impact their specific flights, (2) improves user access to graphic weather products (perhaps by using communications systems such as the Internet), and (3) improves the efficiency of pilot weather briefings by flight service specialists.*

Because of their meteorological training and experience, flight service specialists are better equipped than many general aviation pilots to make meteorological judgments. In fact, many general aviation pilots believe that it is extremely important to have the option of calling an FSS or AFSS and talking to a human weather briefer, especially when weather conditions are marginal or uncertain. As a result, flight service specialists sometimes serve as a critical element of flight safety as they help pilots interpret weather information prior to and during flight.

Recommendation: *Flight service specialists should remain available as a source of preflight and en route weather information for general aviation and business pilots.*

Form and Content of Weather Products

One of the FAA's key goals for the federal aviation weather system is to enable all users to plan for—rather than simply react to—operationally significant weather. The FAA anticipates that accomplishing this goal will involve providing users with weather products that feature improved accuracy, timeliness, and resolution; are tailored to meet specific user needs; present information in ways that users can easily assimilate; and provide different types of users (e.g., pilot and controllers) with consistent information, thereby contributing to shared situational awareness (FAA, 1994b). Shared situational awareness occurs when different users have a common understanding of current and forecast weather conditions. Currently, pilots, controllers, and dispatchers often obtain weather information from different sources that may not agree about the location, duration, or severity of adverse weather.

In some cases weather products generated by the current aviation weather system do a poor job of meeting the needs of pilots. For example, DUATS inundates pilots with a great deal of meteorological data that apply to a broad geographic region in the vicinity of the proposed flight. As a result, it is difficult for users to identify the information that applies to their specific flight. Tailored route-and user-specific weather products are more useful than all-encompassing weather products that make it difficult for individual users to identify the information that applies to their particular situation.

The FAA, NWS, and private weather services are already working to improve the form and content of aviation weather products by developing new products that make greater use of graphics. As illustrated in *Weather for Those Who Fly* (NRC, 1994), graphic weather products can provide users with multiple options for viewing

[10] As a third alternative, pilots can also contact private weather briefing services, which usually operate on a fee-per-use basis. See Chapter 6 (pages 57 and 58) for more information on the role of the private sector in providing aviation weather services.

[11] The total cost of operating FSSs and AFSSs during 1993 was about $350 million. However, these facilities provide a variety of preflight and en route services, and it is difficult to accurately estimate the actual cost of a specific preflight service.

and assessing the current and forecast state of the atmosphere along proposed flight paths. Many graphic weather products are already being tested in applied research laboratories. These new products will be easier for pilots and other users to understand than the long, coded text reports that are common in the current aviation weather system. Future dissemination systems will need to accommodate these products and other changes in the aviation weather industry.

Recommendation: *The FAA should take the lead in developing tailored and consistent graphic aviation weather products that feature improved accuracy, timeliness, and resolution.*[12]

Dissemination to Blots En Route

Pilots need access to better weather information, not more data. For example, pilots preparing to land or take off need concise information to help them make a go/no-go decision. Although important information is often available on the ground, there are few options for transmitting it to pilots in the air. Many airline dispatch offices, air traffic control facilities, and weather forecast offices have access to a wide variety of full-color graphic weather products that display up-to-date local, national, and even global weather information. However, except for voice radio, general aviation aircraft, commuter airlines, and even some air carriers typically have no ability to receive or display weather information en route. In order to improve the dissemination of weather information to pilots, the FAA is attempting to develop a widely acceptable system for en route dissemination of weather information in graphic form. In order to achieve wide acceptance, such a system will need to meet user needs in areas such as:

- Cost of equipment and services. Upgrading or replacing avionics is an expense that owners of commercial, business, and general aviation aircraft are reluctant to make unless there is a compelling economic or safety-related justification.
- Pilot workload. Improved weather information systems will be a mixed blessing if they increase pilot workload. During critical phases of flight, pilots cannot afford to divert very much of their attention from flying the aircraft, especially during adverse weather when up-to-date weather information is most critical. This is particularly true for general aviation pilots, who rarely have a copilot to provide assistance.
- Design features and human factors. New cockpit weather systems should be appropriate to the typical level of pilot training and expertise for each type of aircraft. For example, complex systems can easily overwhelm general aviation pilots who have limited flight experience.
- Access restrictions. Pilots and aircraft owners do not want to be excluded from major airports by requirements for expensive new equipment that they cannot afford.

New dissemination systems should also consider the special needs of small but important user groups such as rotorcraft operators. For example, rotorcraft often engage in search and rescue or medical evacuation missions that use nonstandard flight paths and emergency landing zones that may be miles from the nearest airfield or official weather observing site.

Finding: *The limited capabilities of existing cockpit display and ground-to-air communications systems are the largest technical impediments to improving dissemination of graphic weather information to pilots en route.*[13]

Recommendation: *The FAA-should support ongoing work that addresses shortcomings in cockpit display and ground-to-air communications systems. The FAA should also continue to provide voice radio links to weather briefers on the ground, such as those currently provided by AFSSs, until a practical alternative system is fielded.*

Role of Air Traffic Controllers

There are three types of air traffic controllers:[14]

- En route controllers at ARTCCs (Air Route Traffic Control Centers), who control the movement of en route aircraft operating in accordance with an instrument flight plan.[15] This includes virtually all flights by commercial air carriers.
- TRACON (Terminal Radar Approach Control) controllers, who control the movement of low-altitude aircraft that are between 10 and 50 miles from major airports. More-distant aircraft are the responsibility

[12] See Major Recommendation 3 (Chapter 3, page 39) and Major Recommendation 6 (Chapter 6, page 55).

[13] See Major Recommendation 3 (Chapter 3, page 39) and Major Recommendation 6 (Chapter 6, page 55).

[14] FAA documentation often refers to air traffic control specialists, a term that includes the three types of controllers described above plus flight service specialism, who work at FSSs and AFSSs.

[15] The FAA also offers a flight-following service for pilots operating under visual flight rules. Pilots use the En Route Flight Advisory Service to contact a flight service specialist at an AFSS to obtain weather information. Once a pilot reports his or her position and route, the specialist provides the weather information requested, including observed and predicted weather.

of ARTCC controllers, and close-in aircraft are the responsibility of tower controllers. The FAA operates TRACONs at about 150 airports in the United States (FAA, 1995a).

- Tower controllers, who control the movement of aircraft while they are on the ground, taking off, and landing. Unlike ARTCC and TRACON controllers, who rely on radars to track aircraft, tower controllers in most cases track aircraft visually, although they also have access to radar systems. The FAA operates air traffic control towers at about 400 airports in the United States, and it contracts out control tower operations at about 30 additional airports (FAA, 1995a).

The primary role of air traffic controllers is to separate aircraft from each other and, thereby, avoid collisions between aircraft while they are in the air or on the ground. Pilots—not air traffic controllers—are responsible for separating aircraft from adverse weather. FAA Order 7110.65 (FAA, 1994c) includes the following guidance for air traffic controllers with regard to weather information:

- Become familiar with pertinent weather information when coming on duty.
- Stay aware of current weather information needed to perform air traffic control duties.
- Broadcast a general announcement to advise pilots of the availability of hazardous weather advisories when new advisories are issued. [FAA Order 7110.65 states that controllers should direct pilots to listen to the local Hazardous In flight Weather Advisory Service broadcast or contact an FSS or AFSS to find out what the weather advisory actually says.]
- Solicit pilot reports of weather conditions when requested by other facilities and when specified adverse weather conditions exist or are forecast.
- Issue pertinent information on observed/reported weather. Provide radar navigational guidance and/or approve deviations around weather *when requested by the pilot* [emphasis added].

Thus, even though controllers have a general concern for flight safety that includes the impact of adverse weather, and even though they often advise pilots of hazardous weather that they may be aware of, current FAA procedures do not allow controllers to redirect aircraft movements in order to avoid such weather in the same way that they are required to redirect aircraft to avoid collisions. This situation may have arisen because controllers have never received weather information that is consistently accurate and precise enough to use as a reliable tool for directing aircraft movements. Weather data are available on the radar displays used by ARTCC and TRACON controllers, but it comes from air traffic control radars. These radars are not designed to detect weather; as a result, they are not as precise as weather radars in depicting precipitation. Moreover, during adverse weather, the weather information displayed on the radar may obscure aircraft location data, so controllers may turn off the weather information to ensure they can fulfill their primary function of controlling aircraft movements to prevent collisions.

Pilots, on the other hand, often can use onboard weather radar or simply look out the cockpit window for an accurate view of local weather. Also, individual pilots have a better understanding of the impact of adverse weather on their particular aircraft than do controllers. As a result, pilots are generally in a much better position than air traffic controllers to judge the location of adverse weather relative to their aircraft and determine an appropriate course of action. Nonetheless, general aviation pilots flying under instrument flight conditions often desire and expect controllers to help keep them clear of adverse weather such as thunderstorm cells and hail. Similarly, commercial airline passengers generally expect controllers and pilots to work as a team in keeping their aircraft out of hazardous weather.

Over the years, the focus of the air traffic control system on aircraft control and collision avoidance has resulted in a situation in which air traffic controllers and the FAA, which is heavily influenced by active and former air traffic controllers, seem to have developed a general cultural bias against increasing their involvement with weather and weather-related issues. This bias was repeatedly encountered by the committee as it gathered information from various FAA organizations and individuals. During bad weather, air traffic controllers may be so busy working with aircraft that they have little time to study the weather. For this reason, and because some controllers view weather information as a low priority, they may not be knowledgeable about current and forecast weather conditions in their sector.

Operational procedures reinforce the message that weather is not important to controllers. Even at the ARTCCs, where meteorologists are on duty 16 hours per day, air traffic controllers do not receive a weather briefing prior to the start of their shifts. Instead, a CWSU (Center Weather Service Unit) meteorologist briefs the air traffic control supervisors after the shift starts, and the supervisors then pass along to their subordinate controllers whatever information they feel is appropriate. The timing of these briefings is set by each ARTCC, and they may not occur for an hour or more after the start of each shift. As a result, en route controllers have limited access to weather information, and they may not understand the type of weather conditions that are forecast for their sectors. This limits their ability to advise pilots about weather conditions even when they have the time and inclination to provide such advice. This can be a significant problem for general aviation pilots, who may be relying on controllers for en route weather information.

Many controllers are particularly interested in receiving improved weather information to help them manage traffic flow. For example, pilots will attempt to avoid thunderstorms, and, if controllers can see thunderstorms develop on their radar screens, they can anticipate that pilots of aircraft in their area will start requesting course changes to avoid the storm. Nonetheless, controllers generally prefer to avoid increasing their workload by assuming a larger role in providing pilots with weather information. This could become a contentions issue starting in 1997 when the FAA begins installing new radar display systems for air traffic controllers. These displays will depict data from WSR-88D weather radars. Once pilots learn that controllers have access to reliable, localized weather information, it is likely that they will more often ask controllers about weather conditions.

Finding: *Increasing the ability of air traffic controllers to access accurate weather information would encourage them to monitor meteorological conditions routinely. Increasing controllers' awareness of adverse weather could significantly contribute to the safety and efficiency of the airways.*[16]

Effectiveness of Center Weather Service Units

During 1980 the FAA and NWS established CWSUs at the FAA's 21 ARTCCs to monitor aviation weather conditions and "keep the controllers advised of weather conditions" (FAA, 1994e).

Based on visits to several CWSUs and discussions with a variety of FAA and NWS officials, the committee believes that the utility of individual CWSUs depends to a large extent upon the personalities of the FAA and NWS personnel assigned to each ARTCC. If these personnel work well together and understand the benefit that accurate meteorological information can provide to en route operations, CWSUs can be of significant value. Even so, as discussed above, the effectiveness of CWSUs is limited because the FAA does not require controllers to receive a preshift weather briefing. CWSU effectiveness is also limited because no one in their current chain of command within the NWS (or the FAA) shares their focus on aviation weather. Organizationally, CWSUs are managed by the NWS's regional directors through an intermediate weather office in the vicinity of the CWSU. The committee encountered some managers in this chain of command who voiced little interest in monitoring the performance of their CWSUs. Instead, they relied on the FAA to determine if the CWSUs meet expected standards of performance. The FAA, however, is not a meteorological organization, and it is not structured to evaluate the meteorological performance of individual CWSUs or to suggest ways to take advantage of advances in forecasting techniques.

During 1993, an FAA working group examined three options for improving CWSU effectiveness (FAA, 1994e):

- Close 13 CWSUs and transfer their functions to the 8 remaining CWSUs, which would be recommissioned as Area Weather Service Units.
- Transfer all responsibility for the CWSUs to the FAA so that the staff would become FAA employees. This option could be implemented as part of the current CWSU structure or as part of a consolidation to eight Area Weather Service Units.
- Contract with private weather services to obtain the services currently provided by the CWSUs.

The working group initially recommended proceeding with the option to consolidate the CWSUs, but the FAA seems to have decided to maintain the status quo. Available documentation does not clearly indicate why the FAA has not implemented the working group's recommendation.

Another option for improving the effectiveness of the CWSUs involves the National Aviation Weather Advisory Unit, which is part of the NWS's National Severe Storms Forecast Center in Kansas City, Missouri. During a visit to Kansas City by some committee members, the National Aviation Weather Advisory Unit impressed the committee as the most dedicated, capable, and professional group of operational aviation weather meteorologists that it had encountered within the FAA or NWS.

The NWS is in the process of reorganizing the National Severe Storms Forecast Center and several other weather facilities nationwide. In 1997, this effort will result in the establishment of a new organization, the Aviation Weather Center, which will retain the aviation-related functions of the National Severe Storms Forecast Center, including those currently provided by the National Aviation Weather Advisory Unit. Under this reorganization, the Aviation Weather Center will assume management oversight of the Central Flow Weather Service Unit. As previously noted, this unit supports the FAA's Air Traffic Control System Command Center just as the CWSUs support the FAA's ARTCCs.

Assigning all 21 CWSUs to the Aviation Weather Center would place the CWSUs under the direct control of the most senior official within either the FAA or NWS

[16] The FAA's role in separating aircraft from adverse weather is discussed further in Chapter 6 (see Major Recommendation 7, page 56).

who is focused on aviation weather and has the personal and organizational expertise to optimize the performance of the CWSUs. This approach would tie together the aviation weather community along distinct functional lines within the NWS. In addition, the Aviation Weather Center would be able to transfer new forecasting techniques and software tools that it develops directly to the CWSUs. Most importantly, this approach would centralize responsibility and authority for the performance of the CWSUs with a single, knowledgeable official who could be expected to resolve existing and future issues related to the operation of CWSUs in a timely and efficient manner.

Recommendation: *The FAA and NWS should improve the effectiveness of CWSUs by taking the following actions:*

- *The NWS should place all 21 CWSUs under the organizational authority of the Aviation Weather Center that the NWS is establishing in place of the National Aviation Weather Advisory Unit.*
- *The FAA should challenge CWSUs to improve the level of services that they provide. In particular, the FAA should encourage ARTCC managers and staff to use the full capabilities of the CWSUs, and it should ensure that en route air traffic controllers receive preshift weather briefings from CWSU meteorologists.*

Dissemination to Airport Operators

Airport managers need accurate and up-to-date weather information to minimize the impact of snow and other adverse weather conditions on airport safety and capacity. In particular, timely information is essential to assemble the snow removal crews needed to keep runways open. Airports with on-site weather offices are often able to obtain tailored weather forecasts directly from local forecasters. However, most small airports have never had forecasters stationed on-site. In the future, many large airports will face this same situation as the NWS consolidates its facilities and moves some of its offices off airport property.

Large airports often have on-site weather sensors and the financial resources to procure information from private weather services. Small airports, however, frequently rely on ad hoc methods to obtain the weather information needed to meet operational needs associated with snow removal, lightning, and strong winds. These methods do not necessarily involve the NWS or FAA. As a result, some airports do not always receive critical weather information in a timely or well-organized fashion.

Implementation of new programs to improve the weather information available to airport operators would require additional resources, which may not be available. However, better use of existing programs could also improve the current situation. For example, as noted earlier, the FAA automatically grants licensed pilots access to DUATS. Other prospective users, including the staff of airport operators, must apply to the FAA on an individual basis for approval.

Recommendation: *The FAA should facilitate the ability of airport operators to acquire appropriate weather information by granting their operational staff routine access to DUATS.*

TRAINING

The potential effectiveness of aviation weather systems is significantly curtailed if pilots, controllers, aviation weather forecasters, flight service specialists, and dispatchers are not trained to use them properly. Thus, it is important for the FAA and NWS to develop and provide appropriate training tools for new systems and procedures that they develop. Using these tools, however, is primarily the responsibility of individual users and their employers.

Training plans should include all appropriate user groups. For example, the Advanced Weather Products Generator program included a plan to familiarize air carrier pilots with its new weather products, but this plan did not include similar familiarization efforts for business or general aviation pilots (FAA, 1994a).

Training on specific types of hazardous weather phenomena is especially important in areas where they occur often enough to constitute a significant threat to aviation but not often enough for local pilots, controllers, or meteorologists to become familiar with them during day-to-day operations. Realistic training is also important to avoid the complacency that can develop as a consequence of months or even years without a significant accident. Constant vigilance and attention to potentially hazardous weather are essential to minimize the occurrence of weather-related accidents.

Pilots

Pilots must be able to determine when adverse weather is likely to exceed regulatory requirements for flight or surpass either their skills or the capabilities of their aircraft. Many weather-related accidents take place because pilots use poor judgment in making these determinations. Many of these accidents could be avoided if pilots were more diligent in obtaining preflight weather information; if they were more attentive to meteorological conditions during flight (by observing local weather conditions and obtaining updated weather information by radio); if they had a better understanding of the preflight and en route weather information that they do receive; and if they were able to make better operational decisions regarding the weather prior to flight, en route, and before approaching an airport for landing. Improved meteorological training during initial and recurrent training for pilots has the potential to improve their ability to execute each of these tasks. Similarly, improved training for dispatchers, controllers, and flight service specialists has the potential to improve their ability to understand the weather information they receive and make better operational decisions.

Experience with windshear demonstrates the potential impact of pilot training. During the last few years, the aviation community has conducted extensive training on how to detect and survive windshear events. This seems to have produced a significant reduction in aircraft accidents related to windshear. Nonetheless, avoidable accidents continue to occur as a result of anomalous windshear events and other weather phenomena that have not been the subject of a comparably intensive training effort.

Initial pilot training is primarily a responsibility of prospective pilots and flight training schools. Recurrent training is generally the responsibility of individual pilots, although responsibility for advanced and recurrent training of professional pilots is shared with the companies that employ them. In addition, in order to promote the safety and efficiency of aviation, the FAA is responsible for setting standards for initial and recurrent training, including the level of weather knowledge that pilots are expected to achieve.

Many pilots believe that weather is one of the most difficult and least understood subjects in the student pilot training curriculum (Lankford, 1995). As indicated by the ongoing occurrence of avoidable accidents associated with hazardous weather, traditional methods of teaching weather concepts during initial and recurrent pilot training do not always adequately prepare pilots to make consistently safe operational decisions. The classroom training of many student pilots is focused on passing the FAA's written examination, but it is possible to miss every question in the meteorological section of the written examination and still pass by doing well on other sections. In addition, many of the weather-related questions on pilot examinations focus on the ability of students to decipher the abbreviations used in standard weather messages rather than on their ability to use weather information in making safe operational decisions regarding the weather. As a result, it is not uncommon for general aviation pilots to ask flight service specialists if it is safe to fly, even though it is the pilot's responsibility to make that determination (Lankford, 1995). Recurrent training is available for general aviation pilots to improve their skills, but the experience of committee members who teach pilot safety courses indicates that too many of the pilots that really need this training do not attend the training seminars and courses that are available.

Flight experience is an important aspect of training because it allows pilots to learn how they interact with adverse weather. Pilots should be able to interpret visible signs of adverse weather properly, and they should have the flying skills to avoid or escape from hazardous weather that they do encounter. For example, pilots who will be flying in mountain passes should know how to reverse course when there is minimal room to maneuver because this skill is important if they encounter adverse weather that blocks their path. Nonetheless, most student training flights occur during good weather because instructor pilots are generally reluctant to train student pilots during marginal weather conditions. Furthermore, even though major air carriers use sophisticated aircraft simulators as part of their training programs, most of the training is focused on aircraft malfunctions that most pilots will never experience rather than on weather phenomena that occur on a routine basis. Except for the windshear training that is required by the FAA, most air carriers provide their pilots with no simulator or academic training in meteorology. Similarly, there are few, if any, requirements for general or business aviation pilots to receive recurrent classroom or flight simulator training in meteorology.

Specialized meteorological training is especially important for pilots who need to cope properly with unusual environmental conditions such as mountainous terrain. Low air densities reduce aircraft performance, and strong winds can create adverse flying environments. Thus, accidents sometimes occur in mountainous regions when pilots of small aircraft fail to anticipate the interaction between the terrain, the high-altitude atmosphere, and their aircraft. The general aviation accident rate for the 11 western states that the FAA classifies as mountainous is 40 percent higher than the general aviation accident rate in the other states of the contiguous United States (GAO, 1995a). In many cases, accident investigations have determined that surviving pilots or passengers saw signs of hazardous weather without appreciating the danger to their aircraft until it was too late to take corrective action (Lamb and Baker, 1995).

Dispatchers

Dispatchers have a responsibility to assess weather conditions in terms of regulatory requirements and company guidelines. They are also responsible for providing necessary information to assigned pilots. The training of dispatchers is a joint responsibility of individual dispatch ers, the air carriers that employ them, and the FAA, which sets standards for training and licensing.

Air Traffic Controllers and Flight Service Specialists

Like flight dispatchers, flight service specialists work with pilots to assess weather conditions both prior to and during flight. It is also a common occurrence for air traffic controllers to provide en route assistance to pilots regarding weather conditions even though controllers have limited access to meteorological information. Controllers generally have less meteorological experience than flight service specialists, and controllers have other duties that limit their ability to focus on providing weather information to pilots.

The FAA is directly responsible for the training and licensing of controllers and flight service specialists. For example, the FAA requires that each of its operational facilities establish an annual refresher training program that includes "unusual situations, such as weather affecting flight" (FAA, 1995b). In addition, CWSU meteorologists assigned to some ARTCCs offer voluntary refresher training in meteorology.

Training of air traffic controllers focuses on reading weather products and exchanging weather-related information with pilots. New systems such as the TDWR (Terminal Doppler Weather Radar) and Integrated Terminal Weather System may make it appropriate to increase the level of meteorological training that air traffic control supervisors receive. For example, the TDWR monitors that line controllers use display straightforward alerts that require no interpretation. TDWR terminals for air traffic control supervisors, however, display a great deal of information, including six levels of precipitation, gust fronts, windshear, and microbursts.

Although, the FAA provides training on new systems such as TDWR, it is not always timely and complete. For example, even though three TDWR systems were operational as of May 1995, the FAA had not yet established guidelines for training supervisors in how to use much of the information on their displays (PAI, 1995).

Aviation Meteorologists

Within the meteorological research community, scientific research usually takes precedence over training. The Cooperative Program for Operational Meteorological Education and Training (COMET) of the University Corporation for Atmospheric Research is a notable exception. The mission of COMET, which is funded by the NWS, Air Force, and Navy, is to improve operational weather services through advanced scientific education and training of forecasters and increased interaction between the operational and academic communities. In addition to conventional classroom training programs, COMET develops computer-based learning modules that combine voice, text, graphics, and video in self-paced modules that educate operational forecasters about advances in meteorological science. These modules are a cost-effective means to educate large numbers of geographically dispersed meteorologists without the expense of assembling them for conventional classroom training.

New meteorologists generally have limited knowledge about the special needs of aviation. However, the NWS conducts its own training programs to improve staff skills. Instructor-led courses are taught at centralized locations and on-site at NWS field offices.

Training Improvements

One very cost-effective way to reduce the impact of adverse weather on aviation safety is to improve the effectiveness of initial and recurrent aviation weather training of (1) commercial, business, and general aviation pilots; (2) ARTCC, TRACON, and tower controllers; (3) aviation weather forecasters; (4) flight service specialists; and (5) dispatchers. Training offers great potential for near-term reductions in weather-related accidents. Improved training programs make it possible to improve the effectiveness of current systems, and it generally takes less time to develop and implement new training programs than it does to develop and deploy new weather systems.

Many aviation and meteorological professionals receive initial and recurrent training at universities. Several of these universities currently offer interactive training via satellite to remote sites throughout the United States. Upgrading university educational programs could enhance the skills of many providers and users of aviation weather information. For example, increasing the availability and effectiveness of aviation meteorology courses at undergraduate and graduate institutions would enhance the overall ability of the meteorological community to understand weather phenomena of particular importance to aviation and generate accurate aviation weather forecasts.

In *Weather for Those Who Fly*, the National Research Council recommended that "the Federal Aviation Administration, the National Weather Service, and aviation organizations should collaborate to develop a new curriculum for pilot weather education" that takes advantage of modern pedagogical technology (NRC, 1994). The committee concurs with this recommendation.

Recommendation: *The FAA should take the following actions to improve weather-related training:*

- *Encourage universities, flight schools, and other training facilities to focus initial and recurrent training of aviation weather users and providers on understanding and optimizing the use of available weather information.*
- *Revise federal licensing procedures for pilots, controllers, flight service specialists, and dispatchers to test more effectively the abilities of candidates to use weather information in making safe operational decisions regarding the weather.*
- *Increase the emphasis that weather receives during biennial flight reviews, safety seminars, and refresher courses for designated pilot examiners and flight instructors.*

MAJOR RECOMMENDATION 2

The FAA should provide the leadership needed to develop a comprehensive national training program that improves the practical meteorological skills of users and providers of aviation weather services.

UNMET USER NEEDS

As discussed above, the FAA and NWS could improve aviation weather services by addressing areas of concern related to weather observation, analysis, forecasting, dissemination, and training. In general, the areas of concern expressed in this report validate the results of other activities that the federal government has sponsored during recent years to study the needs of aviation weather users. For example, during December 1993, the FAA sponsored a National Aviation Weather Users Forum that included a wide range of aviation weather users. The 33 highest priority recommendations generated by the users forum fell into 17 categories:[17]

- airmen education and training;
- AWOS (Automated Weather Observing System) and ASOS (Automated Surface Observing System);
- convective activity (observations, forecasts, and dissemination);
- dissemination of en route weather information;
- forecast quality for terminals and off-airport areas;
- icing/freezing level (forecasts, analysis, and dissemination);
- Integrated Terminal Weather System development;
- international weather dissemination;
- observations of cloud bases, cloud tops, and wide-spread low visibility;
- pilot report collection and dissemination;
- predictions of ground deicing effectiveness;
- regulatory review;
- runway visual range observation and dissemination;
- turbulence observations, forecasts, analysis, and dissemination;
- volcanic ash observations, forecasts, processing, and dissemination;
- winds and temperatures aloft observation, collection; and
- windshear/microburst observations.

More recently, on January 9–10, 1995, the Secretary of Transportation hosted an airline safety summit. The safety summit generated seven recommendations related to aviation weather services and research:

- The FAA, NWS, and industry should commit to implementation of the recommendations of the 1993 National Aviation Weather Users Forum [which are referred to above].
- The FAA should appoint a single senior-level manager/office to expedite implementation and coordination of aviation weather systems and service.
- The FAA should establish an elevated standard for airmen's knowledge of weather and the atmosphere.
- A data link ground-to-air communications system should be implemented to facilitate en route dissemination of graphic weather products.
- Icing hazards should be reduced by improving airport deicing facilities and developing new deicing fluids, ice-rejection coatings, and icing-detection systems for aircraft.
- The FAA should improve its processes and organizational capabilities regarding technology development and validation, setting standards, and certification.
- Standardization of weather products provided by AWOS and ASOS should be improved.

User needs are also discussed in the *National Aviation Weather Program Plan* (OFCM, 1992), *The Federal Plan for Meteorological Services and Supporting Research, FY 1995* (OFCM, 1994), and the *Aviation Weather System Plan* (FAA, 1994a). The needs described in these documents are generally consistent with those listed above and elsewhere in this report.

These documents demonstrate that the federal government's effort to improve aviation weather services is not hampered by uncertainty regarding user needs. However, in order to respond to these needs, the federal government must establish and routinely exercise an effective decision-making process to resolve operational issues within

[17] These categories are listed in alphabetical order. The FAA anticipates publishing an action plan during 1995 that responds to and prioritizes the recommendations of the Users Forum.

budget constraints and to establish appropriate goals and priorities for aviation weather research and development.

User involvement in this process is important to ensure that users adequately understand and accept new aviation weather systems during the development process. As the ASOS system has demonstrated, user acceptance can be difficult to achieve after new systems are installed if users perceive that the new systems do not meet their needs.

User involvement is also important to ensure that there is appropriate balance in meeting the needs of the FAA's internal users (e.g., air traffic controllers) and its external users (e.g., air transport, business, and general aviation pilots). The committee is concerned that a recent decision by the FAA to eliminate funding for the Advanced Weather Products Generator, which is focused on improved weather products for pilots and other external users, represents a lack of focus on pilot needs.

Recommendation: *The FAA should take the lead in establishing and aggressively pursuing aviation weather goals and priorities that reflect the positions of other involved parties, including the following:*

- *other federal agencies and departments;*
- *other providers of aviation weather services (e.g., private weather services and state governments); and*
- *user groups, including the unions, associations, and industry groups that represent those who work with the U.S. aviation weather system on a daily basis: air carrier personnel, pilots, air traffic controllers, flight service specialists, meteorologists, and dispatchers.*

Near-term efforts by the FAA and NWS to improve the effectiveness of aviation weather services should focus on the urgent, unmet needs of aviation weather users, which include the following:

- *a comprehensive national training program to improve the practical meteorological skills of users and providers of aviation weather services;*
- *advanced weather products that are relevant, timely, accurate, and easy to comprehend (e.g., graphically displayed);*
- *ground-to-air communications and cockpit display systems for en route dissemination of advanced weather products; and*
- *weather observations and forecasts that offer improved temporal, geographic, and altitude-specific resolution*.

The preceding section on training addresses the first of these four items. The last three are focused on what the committee has identified as the primary unmet user need associated with the current aviation weather system: a lack of widely distributed graphic weather products that allow pilots, controllers, and dispatchers to develop and maintain a consistent view of current and forecast weather conditions.

This situation persists even though current technology could provide this capability. For example, The commercial air-to-ground telephone systems of some airline passenger aircraft provide facilities to connect laptop computers to ground-based commercial computer communications networks that can be used to access a variety of weather information services. Thus, passengers using modem-equipped computers can obtain up-to-date color images of weather conditions, forecasts, radar summaries, and satellite images. In most cases, these products are superior to the weather products that airline pilots can access from the cockpit. Of course, commercial systems do not face the same rigorous flight safety and certification standards as cockpit communications systems. Nonetheless, the committee urges the FAA to take the lead in deploying modern communications systems to improve the access of pilots and other users to advanced aviation weather products.

In order to implement new systems swiftly, the FAA and NWS must efficiently manage the federal procurement system. The GAO determined in 1993 that the FAA's recent major acquisitions were delayed by an average of 5 years, and in almost all cases they experienced significant cost increases (GAO, 1993). For example, the FAA's Advanced Automation System "has met with billion dollar cost overruns and years of delays" (DOT, 1994).

Although "the federal acquisition process takes too long, lacks flexibility and accountability, and results in products and services that cost too much" (DOT, 1994), it is possible to improve existing aviation weather capabilities quickly by relying on currently available technologies. For example, the FAA constructed and equipped the Air Traffic Control System Command Center, which includes a wide array of modern aviation weather information management and display systems, in about 2 years. This effort was comparable in scope and duration with American Airlines' construction of its System Operations Center, which includes its global operations and meteorological departments.

MAJOR RECOMMENDATION 3

The FAA should swiftly exploit current technology to provide consistent and timely graphic weather information to pilots, controllers, and dispatchers.

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4

Research And Development

The FAA should provide the leadership need to support and focus research and development efforts by government, academic, and commercial institutions on key avitation weather issues.

The aim of aviation weather research programs is to improve the accuracy, timeliness, reliability, and relevance of weather information provided to the aviation community. The scientific knowledge and technology exist today to produce dramatic improvements in the quality and formats of weather information for aviation and thus contribute markedly to increased safety and efficiency. As discussed below, a number of individual projects and programs are aimed at important issues opportunities. However, they are not adequately integrated and suffer from funding uncertainties. Leadership and commitment are required to organize the diverse components of the research program and focus them on achieving an effective system for the future.

Advances in aviation weather services start with identification of a hazard, user need, or scientific opportunity. Through improved analysis of existing observations, improved observations, or field observational studies aimed at specific phenomena, a conceptual foundation for new observation, analysis, or forecasting systems is developed. Often this phase involves basic or fundamental research that creates the potential or opportunity for development of new operational procedures or systems. Further work to focus on aviation impact variables and dissemination capabilities is often required to obtain the full benefit of the new understanding or observational capabilities.[1] The manner in which the government currently implements this process is shown in Figure 4-1.

A new aviation weather system that would better meet the needs of pilots, controllers, dispatchers and other users has been envisioned in both *Weather for*

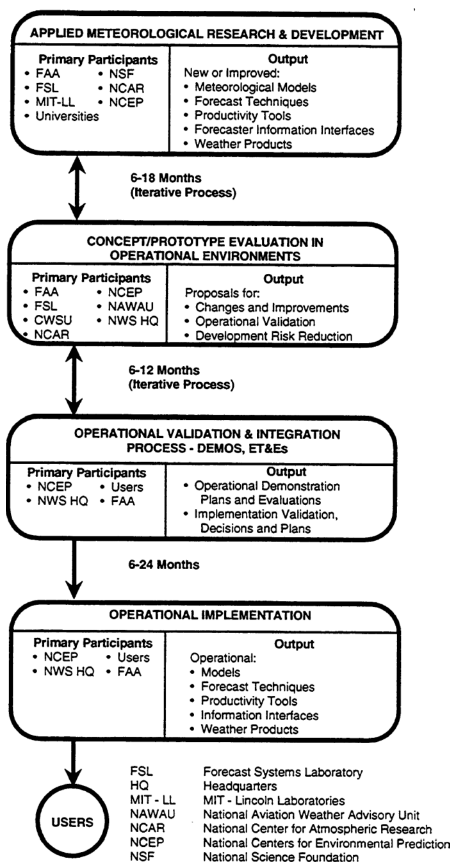

Figure 4-1 Aviation product development and implementation process. (Source: Friday, 1995)

[1] Aviation impact variables are meteorological parameters, such as ceiling, visibility, turbulence, and icing, that are important to flight operations. They are of greatest value when summarized in the form of aviation decision aids, which may be visualizations, graphical representations, or recommendations that support the decision process.

Those Who Fly (NRC, 1994) and *The Aviation Weather System* (FAA, 1994b). The committee iaaa prepared the summary of this vision that appears in the boxed insert. Such a system would address many of the problems that exist today.

THE VISION OF AN IMPROVED AVIATION WEATHER SYSTEM

An improved weather information system that could be available in the near future would allow pilots, controllers, dispatchers, and flight service specialists to access interactive, three-dimensional visualizations of critical aviation impact variables and decision aids that are specific to route, altitude, and decision aids that are specific to route, altitude, and aircraft type and that, in some cases, present alternate routes or altitudes for avoiding adverse weather. A critical feature of this system would be the capability for pilots and controllers to view the same information simultaneously and, when necessary, to communicate about avoidance strategies without having to discuss the weather because both parties would have the same accurate, timely, and relevant information.

This vision includes the following components:

- higher-resolution and more-accurate observations of key atmospheric variables made possible by the modernization of the NWS, including the new WSR-88D Doppler radars now being installed, and by further improvements in observational capability;
- higher-resolution computer analyses and forecasts, including the new Aviation Gridded Forecast System, to produce detailed information of interest to aviation;
- visualizations of these results transformed into aviation impact variables and decision aids by a suite of computer routines known as the Advanced Weather Products Generator (the recent decision by the FAA to cancel the Advanced Weather Products Generator jeopardizes this element of the vision);
- similar summaries of critical conditions in terminal areas created by the Integrated Terminal Weather System; and
- communications capabilities to make these products available to pilots (on the ground and in the air) and to controllers, dispatchers, and flight service specialists.

FEDERAL PLANNING

A comprehensive, long-term research and development program should achieve an appropriate balance between research in support of long-term needs and engineering and technology development in support of near-term acquisition of new operational systems. Most research related to aviation weather is funded by the FAA, including virtually all of the aviation weather research performed by NOAA and the NWS. However, the FAA designates only about 1 percent of its research, development, and engineering budget for weather-related research. Most of the FAA's aviation weather research and development activities are actually funded by the FAA'a much larger facilities and equipment budget, which is focus on near-term acquisition of new systems. Planned reductions in FAA funding for aviation weather research at key government laboratories and universities associated with ongoing research projects will eliminate some research programs and greatly curtail others. Although private industry conducts some research and development, private-sector development is often dependent upon the longer-range research and development that the FAA supports. In addition, the private sector tends to focus on projects that have the potential to produce a near-term competitive advantage. As a result of these factors, most aviation weather research within government and industry is currently focused on technology transfer and product demonstration efforts, and there is less ongoing research than in the recent past. Continued emphasis on product demonstration and technology transfer without the corresponding support of long-term scientific research and concept development will ultimately diminish the ability to develop new systems.

Finding: *It is the proper role of government to develop, fund, and execute a research plan in aviation weather just as it does in many other areas involving the public good.*

Recommendation: *The federal government should make a long-term commitment to aviation weather research as an investment in the future safety and efficiency of aviation.*

Research Organizations

Essentially all of the research and development required to implement the vision described above and to provide other improvements in aviation weather services is supported financially by the FAA. The FAA works with the National Science Foundation to sponsor aviation weather research by the National Center for Atmospheric

Research (NCAR) and three university groups. The FAA also provides funding directly to NOAA's Forecast Systems Laboratory (FSL), the Massachusetts Institute of Technology (MIT) Lincoln Laboratory, and the MITRE Corporation. In addition, NASA and DoD sponsor research and development activities related to aviation weather. Some of this work is aimed at common goals and coordinated to some degree; other parts of the effort are pursued somewhat independently. (See Appendix H, page 93, for additional information on the aviation weather research associated with these organizations.)

The committee has been unable to identify comprehensive mechanisms or procedures now used to coordinate aviation weather research and development efforts by the above organizations. The coordination of FAA, NWS, and FSL efforts is performed at the level of program managers. The NCAR and university efforts are coordinated by the National Science Foundation and the FAA, but current programs are being devastated by funding cuts, and there is little opportunity for researchers with good ideas and potentially important contributions to seek new funding.

Planning Documents

The current aviation weather research and development program is described in the following federal planning documents:

- *The National Aviation Weather Program Plan* (OFCM, 1992);
- *U.S. Weather Research Program (USWRP) Implementation Plan* (USWRP, 1994);
- *FAA Strategic Plan* (FAA, 1994c); and
- *1994 FAA Plan for Research, Engineering and Development* (FAA, 1994a).

A brief summary of each of these documents appears in Appendix H (page 93).

Planning and Coordination

There are numerous planning and coordination groups associated with aviation weather research and development. These include the OFCM (Office of the Federal Coordinator for Meteorology), which operates a number of focused interagency committees; the USWRP program office; the FAA's Research, Engineering, and Development Advisory Committee; and the FAA-NASA Coordinating Committee. Although these groups seem to facilitate the exchange of information among agencies, the committee has not observed that these groups are effective in providing top-level coordination of aviation weather research and development.

Multiagency Planning and Coordination

The committee agrees with the assessment in *Weather for Those Who Fly* that "there is no single, integrated plan specifying the objectives, strategies, schedule, phasing, and budgets to guide the NWS and FAA in achieving the improved aviation weather system envisioned by both agencies" (NRC, 1994). The need for better coordination and planning is also documented in the *National Aviation Weather Program Plan* (OFCM, 1992), which recommended that the federal government develop a separate interagency plan that would accomplish the following:

- Encourage greater interagency coordination of research and development.
- Accelerate the transfer of research and development technology to operational use.
- Define needs for aviation weather observations, forecasting, dissemination, and preparation of weather products.
- Define the responsibilities of individual agencies for conducting research and development projects that fulfill these needs.

Development and execution of plans such as those recommended by the National Research Council and OFCM should include non-government users (e.g., pilots and dispatchers), as well as the operational elements of federal agencies (e.g., controllers and forecasters), to enhance their effectiveness in developing technological solutions that meet user needs and can be quickly integrated into operational systems.

The committee views the DoD as a major player in the collection and dissemination of aviation weather information. However, there is not an effective mechanism for the FAA to advise the DoD of its aviation weather requirements or for the DoD to articulate how its capabilities could enhance the ability of the FAA to meet those requirements. This shortcoming could be addressed as part of a broad effort to improve multiagency planning and coordination.[2]

Recommendation: *The FAA should take the lead in implementing the OFCM's recommendation to develop an interagency plan for aviation weather research and development.*

[2] DoD roles and missions are addressed further in Chapter 6 (page 58).

Bilateral Planning and Coordination: FAA and NOAA

Coordination of bilateral efforts involving the FAA and NOAA is discussed in Chapter 2 (pages 16–19), which concludes that high-level coordination mechanisms for developing and operating aviation weather systems are not as effective as they should be.

Bilateral Planning and Coordination: FAA and NASA

Coordination of bilateral efforts involving the FAA and NASA is supported by field offices that the FAA maintains at two NASA research centers. In addition, NASA and the FAA have established the FAA-NASA Coordinating Committee to provide a means for coordinating interagency research activities. Nonetheless, it seems that planning of aviation weather research projects by the FAA and NASA proceed somewhat independently: NASA is rarely mentioned in the weather sections of the federal aviation planning documents obtained by the committee, and the FSL, which conducts a great deal of aviation weather research for the FAA, has minimal interaction with NASA.

NASA usually initiates aeronautical research in response to industry inputs rather than FAA requirements. In addition, the FAA does not include NASA in its long-range planning process (GAO, 1993). Furthermore, the FAA-NASA Coordinating Committee does not provide top-level planning and coordination of interagency research programs. Rather, program managers within the FAA and NASA who desire to engage in a cooperative effort draft a memorandum of understanding that they can then bring to the coordinating committee for approval. This bottom-up approach provides a formal process that program managers can use to coordinate individual projects, but it does not by itself provide the focus and direction that a top-down approach would provide (GAO, 1993). In addition, interagency friction can develop if NASA does not exercise the coordinating committee process for new research programs that the FAA perceives as falling within its purview.

Planning and Coordination Within the FAA

Responsibility for aviation weather is fragmented within the FAA. Chapter 6 (pages 55 and 56) discusses this issue and recommends an approach for addressing it.

There are no more than three or four professional meteorologists assigned to FAA headquarters, and there are no positions for meteorologists at the FAA's regional offices. This lack of internal meteorological expertise at the FAA is exacerbated by the absence of an effective external mechanism to advise the FAA regarding aviation weather operations and research. The FAA Research, Engineering and Development Advisory Committee, as presently constituted, does not satisfy this need.

Recommendation: *The FAA should augment its meteorological expertise to enhance its ability to plan and implement effective aviation weather services.*

LONGER-TERM RESEARCH PRIORITIES

Observations of atmospheric phenomena and variables are the lifeblood of an effective aviation weather information system. A comprehensive analysis of the plans and opportunities for weather observations that would contribute to improved aviation weather services was provided by the National Research Council in *Weather for Those Who Fly*. In addition to recommending that the schedule for the modernization of the NWS be maintained, the National Research Council urged that several new initiatives be pursued by the federal government, including the development of a network of Doppler radar wind profilers and an improved and modem radiosonde network. This committee endorses those recommendations.

Many of the most significant weather hazards to aviation involve the various phases or changes in phase of water. As reported in *Weather for Those Who Fly*, observations of atmospheric water vapor with greatly improved coverage, resolution, and accuracy would enable dramatic improvements in forecasts of convective activity; cloud variables, such as ceiling height and cloud type; and icing potential. This committee concurs that the rapid development of an effective system for high-resolution observations of atmospheric water vapor should be given high priority.

Other groups have also considered the imperatives for improving aviation weather services and related research. An interagency panel convened by the OFCM recently developed a *National Agenda for Meteorological Services and Supporting Research* (OFCM, 1995), which includes improved aviation weather services as 1 of 10 key focus areas. The *Agenda* points out that it is "critical to improve the resolution and accuracy of weather observations," in part by developing a "mixed network of Doppler wind profilers and modern radiosonde systems as well as further instrumentation of the civil aviation fleet," and it cited "obtaining accurate observations of water vapor over space and time scales significant to aviation" as the "biggest challenge." That panel also pointed out that computer systems capable of assimilating "thousands of times more observations" are essential to "form a high-resolution picture of the atmosphere worldwide" in order to provide "high accuracy, high-resolution, short-term forecasts for aviation."

A longer-term view was taken by the first Prospectus Development Team (PDT) of the U.S. Weather Research Program. Its report identified high-priority basic research opportunities pertinent to improved weather prediction and warning, and it cited the need for improved observations required to address a variety of forecast problems, including those related to aviation weather (USWRP, 1995). The report included the following recommendations:

- "High priority must be given to new water vapor measurements and to research that seeks to delineate the water vapor observations necessary to address specific forecast problems...."
- "Substantial improvements [must be made] in our ability to make in-situ measurements in clouds in the upper troposphere" in order to better understand cloud physical processes involving ice at high altitudes.

The PDT emphasized that "the most difficult aspect of providing aviation guidance is [generating] accurate short-term (0-to 6-hour) terminal and en route forecasts of aviation-sensitive weather parameters such as ceiling, visibility, icing, wind, windshear, and turbulence.... Such forecasts must come from deterministic high-resolution ($\Delta x \leq 10$ km) numerical models" and then be subject to statistical post-processing to remove model biases, account for small-scale effects, and present the results in a probabilistic format that enhances aviation safety and efficiency. The PDT concludes that achieving these objectives will require research and advances in several major areas, including the following:

- improved representations of the physical processes governing the distribution of water substance in numerical models;
- improved data analysis and four-dimensional data assimilation techniques;
- new statistical post-processing techniques; and
- prognostic statistical models.

The PDT points out that this program would constitute a predictability experiment focusing on cloudscale and mesoscale phenomena, with success requiring both technological and conceptual advances. Such success would mitigate some of the most serious consequences of adverse weather for aviation.

STRENGTHENING THE RESEARCH PROGRAM

The committee found considerable evidence that federal coordinating mechanisms for aviation weather research are in some disarray and not configured adequately to implement the vision described above or to manage a continuing program of research leading to improvements in the aviation weather system. Moreover, funding for aviation weather research, especially at the FAA, is uncertain and constantly fluctuating. Current levels seem to be insufficient to conduct an adequate research program, but without a coordinated approach it is difficult to judge what might really be required. There is no deliberate, focused, and prioritized approach in place to allocate research and development dollars effectively within an overall framework designed to improve aviation weather services.

Priorities

The absence of clear priorities is one of the most serious difficulties of the national aviation weather research program. Apparently, there is a lack of attention at the senior levels of the responsible federal agencies, and, as a result, these agencies have not established or defined overall priorities clearly. Thus, the research and development effort is not strongly focused on the highest-priority objectives, and no overall plan exists either within agencies or between agencies.

Moreover, the current research and development process seems to concentrate on short-term requirements rather than long-term needs. Long-term commitments are necessary to convert research results into aviation weather capabilities and products. This is especially true in areas such as (1) understanding and forecasting snowstorms, icing, ceiling, and visibility; and (2) thunderstorm detection and monitoring.

The apparent lack of attention to priorities and long-term needs is especially puzzling in view of the clarity with which the aviation community has repeatedly expressed its needs for improvements in aviation weather services (see "Unmet User Needs" in Chapter 3, page 38).

Funding

The cost of research, training, system installation, and support systems is typically a small part of the cost of new or existing systems, but the effectiveness of current and future aviation weather systems can be greatly diminished without adequate funding for these activities. Consider the following examples:

- The late deployment of the AWOS Data Acquisition System has delayed the commissioning of several hundred ASOS systems installed by the FAA.
- The elimination of FAA funding for the Advanced Weather Products Generator is likely to delay the development of improved weather products that are needed to fully realize the benefit of the aviation weather observation, analysis, and forecasting systems that the NWS and FAA are now acquiring.
- The FAA will be warehousing some of the WSR-88D and TDWR (Terminal Doppler Weather Radar) systems that system contractors are delivering, in part because funds are not available to install and operate them.

Recommendation: *The FAA and Congress should maximize the effectiveness of new aviation weather systems by ensuring that related research, training, system installation, and support systems are funded with a priority equal to that of the system acquisition efforts with which they are associated.*

Leadership

Despite the management and budgetary turbulence buffeting the aviation weather research program, the vision of greatly improved weather information for aviation with concomitant improvements in the safety and efficiency of flight remains viable and compelling. Achieving the vision requires a more focused and coordinated approach by the federal government.

As mentioned in Chapter 2 (pages 14 and 15), current legislation directs the FAA Administrator to identify needs for meteorological services related to aviation and to enhance aviation safety and efficiency by formulating long-range research and development plans, conducting or supervising research, and developing new systems and procedures. Although other federal agencies such as NOAA also have important roles to play with regard to aviation-related meteorological research and development programs, none has the aviation expertise and experience needed to ensure that new aviation weather systems will efficiently meet the operational needs of pilots, controllers, and other users.

Finding: *The FAA is in the best position to provide the leadership, establish the priorities, and advocate the funding required to develop an aviation weather system that meets national needs.*

Process

If the federal government is to meet its manifest responsibility to provide the best-possible aviation weather information for aviation and for air travelers, then it must manage the necessary research creatively, responsibly, and effectively.

Recommendation: *The following steps should be taken to improve aviation weather research and development processes:*

- *The FAA, NOAA/NWS, National Science Foundation, NASA, and DoD should collaborate under FAA leadership to develop, fund, and implement a comprehensive plan for aviation weather research and development with firm objectives and closely integrated program plans and funding commitments. The OFCM (Office of the Federal Coordinator for Meteorology) should facilitate the development of such a plan, but final commitments should be made by agency heads.*
- *The meteorological expertise needed to develop and implement the plan described above could come primarily from NOAA and DoD. However, it would also be prudent to strengthen the FAA's in-house meteorological expertise.*
- *The FAA and NOAA should ensure that aviation weather research and development are closely coupled to operational components of these agencies so that new concepts and new ideas can be swiftly integrated into ongoing operations.*
- *The aviation weather research and development process should seek continuing and in-depth involvement with all users, especially the pilots, controllers, forecasters, and dispatchers who depend on weather information to facilitate safe and efficient operations.*

MAJOR RECOMMENDATION 4

The FAA should provide the leadership needed to support and focus research and development efforts by government, academic, and industrial institutions on key aviation weather issues.

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5

Regional Requirements

Air transportation in Alaska illustrates special regional needs for aviation weather services that the national system does not meet. The FAd should take the lead in responding to these needs.

Some geographic regions of the United States have environmental conditions and user needs that vary significantly from national norms in the geographic density of weather observing sites, topography, availability of surface transportation, and other factors that accentuate the impact of adverse weather on aviation. Accurate forecasts are difficult to generate in areas where the density of observational data is very low or where complex topography generates localized, small-scale weather phenomena. In addition, these factors often reinforce each other. For example, mountainous regions generally have a high level of local weather variability, a low density of weather observing sites, and a sparse or nonexistent road network. In regions that have no surface transportation network, aviation may be the only practical source of food, fuel, and health services; and continuity of air service may be essential to normal life.

Funding constraints limit the resources that federal agencies can devote to meeting the aviation weather needs of regions with special environmental conditions. In addition, the federal system for providing aviation weather services is based on conditions and needs that prevail in much of the nation. As a result, the federal aviation weather system, in some cases, does not fully respond to localized needs for aviation weather services. In fact, nine states fund and operate their own weather observation and dissemination systems to meet local weather needs.

Alaska, more than any other region of the United States, seems to have an aviation environment that illustrates how regional needs can differ from national norms. Therefore, the committee considered the special needs of Alaskan aviation in some detail. However, the committee recognizes that Alaska is not the only region of the United States that has special needs. Variations in aviation weather regional requirements also exist in other areas, such as the islands of Hawaii and remote or mountainous regions in the west and northeast. However, conducting an exhaustive survey of regional requirements was outside the scope of this study. As a result, this report does not contain definitive comments on regional requirements throughout the United States. Rather, the report uses the lessons learned from Alaska to discuss general issues associated with regional variations in environmental conditions and aviation weather user needs.

Much of the information that the committee collected regarding the extent to which federal aviation weather services meet the special needs of Alaska was anecdotal. However, the committee contacted dozens of aviation weather users and providers in every region of the state and discovered a broad consensus among members of the aviation community regarding many aspects of aviation weather services in Alaska. The contents of this chapter and Appendix I (page 96), which includes additional information on Alaskan aviation, are based on the committee's careful consideration of these consensus viewpoints, along with the observations and personal experience of committee members.

REGIONAL VARIABILITY IN AVIATION SAFETY

One way to assess regional variability in aviation is to examine differences in aviation safety. For example, as illustrated in Figure 5-1, *general aviation in Hawaii, the 11 western states that the FAA classifies as mountainous, and Alaska is 27–600 percent more dangerous than in the rest of the country*. The situation is most critical for VFR (visual flight rules) flights, which dominate Alaska's commercial and private aviation network. At the time of the committee's visit to Alaska, the 142 most-recent aircraft accidents and incidents in Alaska all involved VFR flights; none occurred during IFR (instrument flight rules) flights.

Some of the increased risk associated with flying in Alaska and other mountainous regions is a natural conse quence of the unusually harsh terrain and weather. However, as indicated below, there are other factors associated with the air transportation system that seem to contribute to higher accident rates experienced by general aviation pilots in mountainous regions.

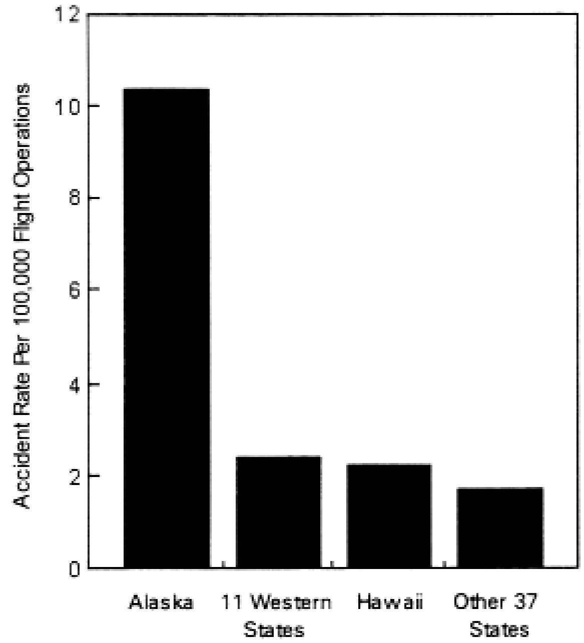

Figure 5-1 General aviation accident rates by region of the United States. (Source: GAO, 1993)

THE ALASKAN EXAMPLE 1980 AND 1995

After traveling to Alaska and assessing the ability of existing federal aviation weather systems to satisfy regional user needs, the committee obtained a copy of a study that the NTSB (National Transportation Safety Board) published in 1980 (NTSB, 1980). That study examined the safety of air taxi operations in Alaska. Comparison of the NTSB study with the current state of affairs in Alaskan aviation indicates that most of the regional issues and concerns noted by this committee have existed for at least the past 15 years, and it does not seem that the FAA, NWS, state of Alaska, and other involved parties have been very successful in addressing them. Based on its own investigation of Alaskan aviation, the committee concluded that each of the following quotes from the 1980 NTSB study are still true today:

> VFR flight in adverse weather is not uncommon in Alaska.... The risk of losing unrecoverable business often results in pressure on the operator or pilot to fly when good judgment dictates otherwise.... The lack of FAA inspectors permanently on-site at the regional hub airports—FAA inspectors are permanently assigned only in Anchorage, Fairbanks, and Juneau—does little to discourage these unwarranted and often illegal flights. There is no one of authority available to discourage or stop those operators or pilots with a "bush mentality" from flying when others choose not to do so.
>
> The FAA appears to believe that the most serious safety problem is operator and pilot attitude, and the operators and pilots seem to feel that the FAA, rather than working with them to solve their problems, is "violation" oriented.
>
> Another problem that operators and pilots face is inadequate reporting of weather conditions. The problem is twofold and involves both inadequate official weather observations and inadequate communication of the observations. Many operators believe that the official weather reporting system set up by the NWS, using certified weather observers, has deteriorated over the years.... Remote automated weather observations stations were considered by the operators as being inadequate....
>
> To alleviate the communication problem and the lack of a certified weather observer in a particular village, many operators have set up their own weather observation and communications networks.... However, even this private system is not perfect.... Sometimes weather conditions and runway conditions are reported as being significantly better than they are.... Further, the weather observers usually are not trained or certified by the NWS. Thus, the flights based on these weather data are often in violation of Federal Aviation Regulations. This system has been tolerated because of the lack of an alternative system.
>
> While a dialogue exists between the FAA and the State DOT/PF [Department of Transportation and Public Facilities], the degree of coordination among the state and federal agencies (particularly the FAA and the NWS) does not appear to be sufficient to develop and implement an adequate aviation infrastructure.

The persistence of these factors indicates that, at least in Alaska, some of the accident risk faced by general aviation aircraft in mountainous regions is the direct result of (1) the ineffectiveness of the current regulatory system in countering economic factors that induce air carriers and air taxis to conduct VFR operations without complete weather information and in questionable weather condi tions and (2) shortcomings in the official aviation weather system that force VFR pilots to obtain much of their weather information from "black market" sources of questionable reliability. Until the responsible government agencies correct these deficiencies, the flying public in regions such as Alaska will continue to experience a reduced level of safety.

Finding: *VFR aviation in Alaska plays a role of uniquely vital economic and social significance However, the safety and efficiency of aviation in Alaska is limited by deficiencies in the aviation weather system that have persisted for at least the last 15 years.*

IMPROVING REGIONAL SERVICES

The FAA needs to recognize that aviation in regions such as Alaska is different than in the rest of the country. The committee interviewed dozens of pilots, dispatchers, and other members of the aviation community in Alaska. They generally concurred that the greatest operational need of the Alaskan aviation weather system concerns low-level en route and terminal observations and forecasts, especially at remote airfields and in microclimates such as mountain passes that serve as air routes. They recommended accomplishing this goal by providing more certified weather observers and more automated stations to provide observations where there are no trained observers. (Most users did not want automated systems to take over observing duties at locations where certified weather observers are already stationed because they view human observers as the best source of weather observations.) Additional options for improving observation and dissemination are listed at the end of Appendix I. All have advantages and disadvantages; none, by itself, will fully respond to current needs.

Initiating a comprehensive program to improve weather observing and dissemination systems would clearly benefit Alaskan aviation. However, the long-term persistence of many of the shortcomings in the current aviation weather system indicates the presence of a more basic problem: the lack of effective leadership to coordinate the efforts of responsible state and federal government agencies regarding the basic issues afflicting Alaskarl aviation and how to address them. The current system features a variety of interests that tend to work independently—and often at cross purposes—to satisfy their individual needs without an adequate understanding of the overall situation. Users want better service. State officials in Alaska believe responsibility for aviation weather services rests with the federal government. Federal officials take limited action and cite federal regulations, agency policies, limits on their authority, the shortcomings of other federal agencies, budgetary constraints, and decisions made by their predecessors. There is no formal process for identifying what level of service users need, how well the current system meets those needs, or how future changes will alter the level of service. It does not seem that aviation weather service providers are strongly motivated to satisfy user needs, and users do not seem overly concerned with the challenges faced by service providers in trying to accommodate their needs with increasingly limited resources. As long as the interested parties view each other as adversaries, it seems unlikely that significant progress will be achieved.

On the other hand, significant progress would be possible if the interested parties worked together to explore both conventional and innovative options for improving regional aviation weather services. The federal government clearly has a key role to play. As described in chapters 2 and 3, the federal government provides many aviation weather services and regulates the use of weather information by pilots, controllers, and dispatchers. In addition, state governments, which tend to be well informed about and responsive to local needs, also have an important role to play in resolving issues concerning available aviation weather services.

Recommendation: *The FAA, on behalf of the federal government, should take the lead in finding the means to meet special regional needs for aviation weather services. In regions that have special needs, the FAA should establish a team that includes other responsible federal and state government agencies, the local aviation industry, airport operators, pilots, professional organizations, and local communities to identify, assess, and properly respond to these needs. Such a team should address the following areas:*

- *The overall aviation weather goals and priorities of the local user community and how they differ from those that drive the national aviation weather system.*
- *The role that each of the involved parties should play in meeting these goals.*
- *The extent to which it is practical to modify the structure and processes of the national aviation weather system to accommodate special needs of local users. There should be an appropriate balance between the competing goals of (1) maximizing the effectiveness of the regional system, which might call for highly customized services, and (2) minimizing regional variances in the national system so that users are not confused by differing procedures as they travel throughout the country.*
- *The optimum methods for allocating available resources. Existing aviation weather systems would*

clearly benefit from the allocation of more resources, and it may be appropriate for federal and state agencies to request that their future budgets contain additional funds. First, however, it is imperative to determine if service can be improved by reallocating currently available resources.

After addressing the above areas, the FAll should take the lead in assuring that appropriate action is taken. The FAA should also initiate appropriate statutory and regulatory variances to accommodate the agreed-upon plan of action.

Recommendation: *State governments should play a role in responding to special regional needs for aviation weather services that is second only to that of the federal government.*

MAJOR RECOMMENDATION 5

The FAA should provide the leadership to meet regional needs for aviation weather services with regional solutions.

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6

Future Roles and Missions

The best approach for improving aviation weather services and related research is for the FAd to fulfill the lead agency role vigorously. Stronger leadership by the FAd would enhance cooperation and coordination among other parties involved in optimizing current and future aviation weather systems and services.

Federal aviation weather services are provided by multiple agencies working together in accordance with generally accepted roles and missions. However, as discussed in chapters 2 through 5, current arrangements for carrying out these roles and missions should be improved to respond more fully to user needs. In addition, the responsibilities of individual agencies for research and development related to aviation weather observations, forecasting, dissemination, and the preparation of weather products are not well established. Efforts to improve the federal aviation weather program should focus on developing and implementing a well-defined strategy that includes a prioritized list of top-level objectives and a practical approach for coordinating interagency efforts.

FUTURE ALTERNATIVES

The overall safety and effectiveness of the aviation weather services that the federal government currently provides is a tribute to the dedication and skill of the midlevel managers and line personnel within the FAA and NWS who provide aviation weather services on a day-today basis. However, greater attention by more senior officials would create significant opportunities to improve the effectiveness and efficiency of aviation weather services nationally and regionally.

With regard to agency roles and missions, national policy makers have numerous options for improving the ability of the federal government to resolve existing and future issues. These options range from maintaining the status quo to making radical changes. The committee examined and evaluated seven alternatives that, in the opinion of the committee, encompass the most feasible and reasonable possible courses of action:

1. Maintain the status quo.
2. Maintain the status quo, with a senior focal point within the FAA for aviation weather.
3. Shift additional federal responsibilities for aviation weather services and related research to the FAA.
4. Shift additional federal responsibilities for aviation weather services and related research to the NWS.
5. Establish a new organization to provide aviation weather services and conduct related research.
6. Assign primary responsibility for aviation weather operational services and related research to two different agencies.
7. Increase the effectiveness with which the FAA serves as the lead agency for aviation weather services and related research.

These alternatives form the basis for the committee's recommendations on future agency roles and missions for aviation weather. Appendix J (page 107) describes and assesses alternatives 1 through 6. After consideration of these alternatives, the committee strongly favors implementation of Alternative 7, which is described below:

Alternative 7. The FAA would vigorously assume overall responsibility for coordinating and overseeing the planning and execution of aviation weather services and related research by the federal government. The FAA would also coordinate the timely resolution of existing and future aviation weather issues with other federal, state, and private organizations. Furthermore, an FAA associate administrator would be given overall responsibility for coordinating and overseeing the planning and implementation of aviation weather services and related research within the FAA. Agency roles would remain largely as currently assigned, and federal agencies would retain individual responsibility for executing their assigned roles. However, the FAA would play a more definitive role in ensuring that actions needed to improve services now and in the future are identified and executed in a timely fashion.

Advantages. This alternative offers distinct, near-term advantages. It clearly defines which agency has primary responsibility for improving aviation weather services. By providing a focal point for leadership, accountability, and a sense of ownership, this alternative would increase the visibility of aviation weather services and related research within the FAA and the federal government as a whole. The FAA would assume accountability for how well the overall aviation weather system meets user needs, and it would take the lead in coordinating the efforts of all involved parties to respond to urgent unmet needs.

This alternative would improve the FAA's internal coordination of aviation weather services. Developing a single FAA position on broad aviation weather issues can involve the offices of the FAA associate administrators for (1) air traffic services, (2) regulation and certification, and (3) research and acquisition. For example, the Associate Administrator for Research and Acquisitions has an acquisition plan that includes aviation weather systems, but it is not fully integrated with other elements of the FAA that manage regulation, certification, and day-to-day operations.

Except for the FAA Administrator and Deputy Administrator, no FAA official has the authority or responsibility to lead the FAA in developing a consensus position on issues that involve two or three associate administrators. Officials from the NWS, other federal agencies, and user groups are often frustrated when they try to resolve aviation weather issues because there is no single point of contact within the FAA who can bring issues to closure. Instead, officials from outside the FAA must deal with several different FAA representatives who often do not agree among themselves about what the FAA position is with regard to a particular weather-related issue.

Designating a single point of authority for weather services would (1) improve aviation weather leadership and focus within the FAA, (2) improve the FAA's ability to resolve aviation weather issues in a timely fashion, (3) reduce the frustration currently experienced by outside agencies and the private sector when attempting to resolve aviation weather issues with the FAA, and (4) facilitate efforts by the FAA to carry out its existing memorandum of agreement with NOAA (FAA, 1977), particularly with regard to providing the NWS with a single agency-wide list of aviation weather requirements. The merit of this approach was recognized by the Department of Transportation's 1995 Aviation Safety Conference, which recommended establishing a single senior official and/or office for aviation weather systems and services within the FAA (DOT, 1995).

Any attempt to improve aviation weather services through major changes in agency structure, shifts in the oversight responsibility of congressional committees, or fundamental changes in the budgetary process could take years to achieve and, in the end, might not succeed. Alternative 7 does not involve such changes; the executive branch could implement it simply by issuing an appropriate executive order or OMB circular. Nonetheless, Alternative 7 would facilitate the implementation of current policies as well as the recommendations contained in this report and other documents.

Disadvantages. Simply designating a lead agency will not improve the current level of services. Associate administrators within the FAA and corresponding officials within NOAA, the NWS, NASA, and DoD must accept the proposed working arrangements if they are to be effective. The success of Alternative 7 would also require a strong commitment by the FAA Administrator, the FAA associate administrator designated to take responsibility for aviation weather services, and other headquarters and field organizations within the FAA, NOAA, and the NWS. This approach also would probably require the FAA to hire additional personnel with technical and managerial expertise in meteorology.

Assessing the Alternatives

The key constraints on improving aviation weather services are primarily institutional (e.g., related to agency roles and missions) and political, not technological, legal, or fiscal. For example, although diminishing budgets make it difficult to improve aviation weather services, there are several options for pursuing significant improvements even within existing budget constraints, including the following:

- reexamining funding priorities (see Chapter 3, pages 38 and 39);
- improving the management and coordination of research and development programs so that new systems are able to achieve stated goals in terms of technical performance and cost savings (see Chapter 4, pages 42–46, and the discussion of lessons learned from the ASOS acquisition in Chapter 3, page 26); and
- providing effective leadership for aviation weather services and research.

Most of the recommendations contained in this report are based on information that is readily available from other study reports, federal documents, and interviews with knowledgeable members of the aviation and mete orological communities. It is not difficult to determine what types of services users need or the areas of research that are needed to provide those services. Meeting user needs, however, is often impeded by a lack of consensus and cooperation among the government agencies, private weather services, research organizations, and user groups involved in aviation weather. As a whole, these organizations have the resources to improve aviation weather services significantly, but only if they act in a concerted effort so that their actions are mutually reinforcing. Capable leadership and the personal accountability that comes with a sense of ownership are needed to build consensus and coordinate the overall effort to provide aviation weather services and conduct related research.

Stronger leadership will directly improve the process by which aviation weather services are planned and implemented. The FAA, which has the legislative charter to improve the safety and efficiency of the air transportation system, is in a better position to demonstrate strong leadership for aviation weather than NOAA, the NWS, NASA, or other agencies that have some involvement in aviation weather services or related research.

Without stronger leadership, other actions to improve services are unlikely to achieve their full potential. For example, it might be possible to improve the effectiveness of aviation weather services and related research by transferring some functions between the FAA and NWS, as a modest implementation of alternatives 3 or 4. However, the committee foresees only modest gains in efficiency as a result (see Appendix J). Furthermore, assessing the merits of adjusting agency roles and missions is the type of activity that is most likely to succeed if strong leadership is available to provide direction and encourage interagency cooperation. As a result, the committee believes that this is the sort of issue that is best examined after Alternative 7 is implemented and a mechanism is in place to develop an accepted course of action expeditiously.

ROLES AND MISSIONS

As described above, the committee believes that the FAA should vigorously fulfill the lead agency role with regard to aviation weather services and supporting research. Other federal agencies, state governments, and the private sector should follow the FAA's lead and work together to optimize current and future aviation weather systems and services.

The specific aviation weather functions that the FAA, NWS, DoD, and other agencies currently provide seem to be generally well suited to their respective missions and capabilities. The committee recommends that they continue to provide those functions, as described below.

Observation. The federal government (i.e., the NWS and FAA) should retain primary responsibility for making required weather observations by assigning government employees or arranging with third parties to provide this service. This view is consistent with Title 49 of the U.S. Code of Federal Regulations, which directs the Secretary of Commerce, in cooperation with the FAA Administrator, to provide meteorological services and make weather observations necessary for aviation safety and efficiency. This view also reflects the consensus viewpoint among government and industry personnel interviewed by the committee.

Analysis. The NWS should continue serving as the principal source of analyzed aviation weather data within the United States in accordance with the NWS's historic role and current statutory responsibilities.

Forecasting. The NWS should continue as the primary source of aviation weather forecasts intended for general use by the aviation community. Private industry should continue to offer tailored forecasts to airlines, the business aviation community, and other users who are willing to pay for specialized, value-added products. In addition, the FAA and NOAA should push forward in the cooperative development of systems such as the Aviation Gridded Forecast System and Advanced Weather Products Generator. These systems would allow both government and private weather services to provide improved weather products that are tailored to the needs of individual users.

Dissemination. The FAA should continue to serve as the primary federal agency responsible for ensuring that pilots, controllers, and other members of the aviation community have adequate access to available weather information.

Research. The committee concluded in Chapter 4 that it is the proper role of government to develop, fund, and execute a plan of basic research in aviation weather just as it does in many other disciplines. Therefore, the committee recommended that the FAA take the lead in implementing the recommendation of the OFCM (Office of the Federal Coordinator for Meteorology) to develop an interagency plan for aviation weather research and development that would accomplish the following goals:

- Encourage greater interagency coordination of research and development.
- Accelerate the transfer of research and development technology to operational use.
- Define needs for aviation weather observations, forecasting, dissemination, and preparation of weather products.
- Define the responsibilities of individual agencies for conducting research and development projects that fulfill these needs (OFCM, 1992).

FAA

The committee's recommendations concerning FAA roles and missions fall into two categories: leadership and separating aircraft from hazardous weather.

Leadership

Aviation safety and efficiency require effective decision making by pilots, air traffic controllers, and other users of aviation weather information. Vigorous leadership within the federal government is necessary to ensure that aviation weather services support this goal by meeting user needs. Because aviation safety and efficiency are primarily the responsibility of the FAA, the FAA should provide this leadership. Thus, the FAA should exert stronger leadership in every area of its responsibility that contributes to the provision of accurate and timely weather information.

Recommendation: *As part of its effort to provide necessary leadership, the FAd should accomplish the following tasks:*

- *Specify national and regional aviation weather requirements.*
- *Organize multiagency participation in aviation weather research, operations, and training.*
- *Justify aviation weather budget requests.*
- *Orchestrate a coordinated aviation weather research and development program.*
- *Improve the understanding and use of weather information by aviation users.*
- *Provide day-to-day dissemination of weather information to aviation users.*
- *Respond to the recommendations contained in this report and in* Weather for Those Who Fly *(NRC, 1994)*.

Because the need for stronger leadership is imbedded within every aspect of the federal aviation weather system, the committee's most important recommendation is for the FAA to execute the lead agency role vigorously.

MAJOR RECOMMENDATION 6: THE PRIMARY RECOMMENDATION

The FAA should provide the leadership, establish the priorities, and ensure the funding needed to improve weather services for aviation users and to strengthen related research.

The recommendations contained in this report do not require the FAA to increase its role significantly in providing or funding aviation weather services, systems, or related research. Rather, they are intended to improve the manner in which the FAA and the rest of the federal government execute their current responsibilities for providing a safe and efficient system of air transport.

Providing stronger leadership in aviation weather would require a shift in the FAA's culture, which is currently focused more on preventing aircraft collisions than on keeping aircraft out of adverse weather. In addition, other organizations must accept the FAA's leadership for the recommended approach to work. However, motivating the FAA to provide effective leadership is likely to be more difficult than. convincing other organizations to cooperate in developing a more-effective aviation weather system. For example, the NWS is motivated to cooperate by ongoing budget reductions and the reality that most of its aviation-related activities are directly funded by the FAA. To ensure that the FAA and other agencies accept the FAA's leadership role, the executive branch should issue appropriate guidelines to the Department of Transportation, Department of Commerce, and other federal departments involved in aviation weather.

Recommendation: *The executive branch should formally designate the FAd as the lead federal agency for ensuring the effectiveness and efficiency of the national aviation weather system.*

Although it is important that the FAA provide strong leadership, aviation weather services involve a wide variety of other users and providers. To be most effective, federal planning efforts should consider the viewpoints of these other interested parties.

Recommendation: *The FAA should seek a broad consensus on aviation weather goals and priorities with (1) other federal agencies: (2) other providers of aviation weather services (i.e., private weather services and state governments); (3) research organizations; and (4) user groups, including the unions, associations, and industry groups that represent those who work with the U.S. aviation weather system on a daily basis: air carrier personnel, pilots, air traffic controllers, flight service specialists, meteorologists, and dispatchers.*

Just as capable leadership is needed to coordinate interagency activities related to aviation weather services and related research, capable aviation weather leadership is needed within the FAA, especially if the FAA is to assume a stronger role in aviation weather. Accordingly, a single official with the authority to develop internal agency-wide positions on broad weather-related policy issues should assume a leadership role for aviation weather within the FAA. The organizations headed by the FAA's key associate administrators have different priorities, interests, and cultures. Weather functions are dispersed among these organizations in various offices that present no unifying nucleus. In addition, issues related to aviation weather require resolution at the associate administrator level. Thus, to be most effective, the designated official should be an associate administrator. This could be either a new position (e.g., an Associate Administrator for Aviation Weather) or an existing position (e.g., the Associate Administrator for Air Traffic Services or the Associate Administrator for Regulation and Certification). Regardless of which approach is selected, it is important to ensure that the designated associate administrator is *given the authority and possesses the determination* to increase the visibility, effectiveness, and priority of aviation weather services across the FAA.

The designated associate administrator need not assume line management authority over all FAA activities that impact aviation weather. However, he or she should be responsible to the FAA Administrator for responding to weather-related issues by timely development of coordinated positions that include inputs from other associate administrators and outside agencies, as appropriate.

Recommendation: *The FAA Administrator should designate an associate administrator to assume overall responsibility for carrying out the FAA's lead agency role for aviation weather and to serve as a single focal point within the FAA with the authority to provide effective internal and external coordination of aviation weather services and related research programs that involve the FAA.*

The committee does not believe that designating the FAA to play a stronger role in planning and coordinating aviation weather activities—or designating a single FAA associate administrator to play a similar role within the FAA—requires a significant shift in personnel or change in organizational structure. As noted by the *Air Traffic Control Corporation Study*, during the decade prior to that study the FAA had "attempted 24 reorganizations and reforms without solving its fundamental problems" (DOT, 1994). The committee agrees that reorganizing the FAA or other organizations will not itself resolve the basic issues associated with aviation weather services. More important than the organizational structure selected to manage aviation weather services is the need to ensure that the individuals selected to manage aviation weather activities have the expertise, inclination, resources, and authority to resolve issues in a manner that meets the needs of all involved parties.

Separating Aircraft From Hazardous Weather

Chapter 1 describes the impact of weather on aviation safety and efficiency. Chapter 2 notes that Title 49 of the U.S. Code of Federal Regulations requires the FAA "to provide for the safe and efficient use of the [national] airspace." Chapters 3 and 4 discuss how advanced aviation weather services and systems will become available in the next few years to increase the accuracy and timeliness of weather information that is available to all users, including air traffic controllers. As described by FAA Order 7032.15 (see Scenario Two in Appendix F), these new services and systems represent an opportunity for the FAA to enhance aviation safety by assuming a more proactive role in separating aircraft from hazardous weather.

As described in Chapter 3, the responsibility for keeping aircraft out of hazardous weather rests with pilots. However, as illustrated by accidents such as the 1994 crash of USAir Flight 1016 in Charlotte, North Carolina, pilots—and their passengers —would benefit if air traffic controllers were more cautious about clearing aircraft to operate in areas where hazardous weather is known to exist (see page 7). This is especially true in cases where controllers have weather information that is more current and complete than the information available to pilots. The committee recognizes that additional responsibilities associated with separating aircraft from weather should not interfere with the ability of controllers to carry out their current responsibilities, which are also critical to aviation safety. The committee also accepts the need for pilots to retain ultimate responsibility for the safety of their aircraft. Nonetheless, in light of ongoing advances in weather observing and forecasting systems, the committee recommends that the FAA prepare to assume a greater role in separating aircraft from hazardous weather, including adjusting the functions of air traffic controllers. As part of this effort, the FAA should work closely with other involved parties (e.g., pilots, owners, and operators of private and commercial aircraft) to ensure that proposed changes are likely to be effective and strike an appropriate balance between safety and efficiency.

MAJOR RECOMMENDATION 7

The FAA should adopt the philosophy that weather services are an important part of its air traffic responsibilities; it should develop procedures and weather products to improve the ability of pilots and air traffic controllers to ensure that aircraft avoid hazardous weather.

NOAA/NWS

Aviation weather services are important to the safety and efficiency of aviation. As such, they serve a broad public interest that is recognized in the statutory requirements for the Secretary of Commerce, as the President's senior official in charge of NOAA and the NWS, to "promote safety and efficiency in civil air navigation to the highest degree" and to "give full consideration" to the recommendations of the FAA Administrator for "providing meteorological service necessary for the safe and efficient movement of aircraft in air commerce" (Title 49). Accordingly, the NWS should continue to ensure the availability of accurate and comprehensive meteorological data and weather forecasts that meet the needs of pilots, controllers, and other aviation weather users. However, the NWS has many other meteorological responsibilities, such as providing agricultural weather services and maintaining climate change records. Thus, the NWS should also assess the impact that proposed changes in aviation weather services might have on these other areas.

The meteorological data collected by the NWS and the weather forecasts and warnings that it generates are essential parts of the aviation weather system. For example, only four U.S. passenger airlines operate their own meteorology departments. The rest depend upon weather forecasts and other products produced by (1) the NWS and (2) private weather services, which use data and information collected and/or generated by the NWS. Even those airlines that maintain their own meteorology departments work in partnership with the NWS to ensure the safety of the flying public. Airlines concentrate their forecasting efforts on their major hub airports; they depend upon NWS forecasts for most destinations. In addition, the NWS provides the FAA with the weather warnings that it uses to alert pilots about dangerous weather conditions.

MAJOR RECOMMENDATION 8

The NWS should continue to meet FAA-determined requirements for weather services as part of its responsibilities for atmospheric observations, analyses, and forecasts.

As already noted, individuals selected to manage aviation weather activities should have the expertise, inclination, resources, and authority to resolve issues in a manner that meets the needs of all involved parties. As discussed in Chapter 3 (pages 34 and 35), the staff of the NWS's National Aviation Weather Advisory Unit, which is being transformed into the Aviation Weather Center, impressed the committee as the most dedicated, capable, and professional group of operational aviation weather meteorologists that committee members encountered within the FAA or NWS. Increasing the ability of these meteorologists to oversee aviation weather operations at other NWS facilities would probably improve the effectiveness of the aviation weather services that the NWS provides to the FAA and other users.

Recommendation: *The Aviation Weather Center should be established with expanded authority to oversee aviation weather services within the NWS. At a minimum, this should include oversight of the NWS's 21 CWSUs (Center Weather Service Units). The NWS should also explore other options for using the Aviation Weather Center's specialized capabilities.*

Private Sector

Private weather services play a minor role in making weather observations. Most weather observations are provided by the federal government, state governments, or private companies—such as air carriers—that need additional weather information to meet operational requirements. However, private weather services play an increasingly significant role in weather analysis and forecasting, dissemination of weather information, and generation of weather products. Furthermore, the role of private weather services has been steadily increasing as emerging technologies have enhanced their capabilities, especially with regard to the provision of tailored weather products for specific customers and applications.

The expanding role of private weather services is consistent with current NWS policy, which states that "the NWS will not compete with the private sector when a service is currently provided or can be provided by commercial enterprises, unless otherwise directed by applicable law. . . . The NWS firmly believes that the private weather industry plays an important and essential role as a partner in ensuring that the nation receives the full benefit of weather and hydrometeorological information for promoting protection of life and property and economic prosperity" (NWS, 1993). However, this policy does not describe how the federal government intends to use the growing capabilities of private aviation services to improve the quality of federal aviation weather services.

The FAA also seems comfortable with a larger role for private weather services. For example, the FAA views dissemination of preflight weather information as one area in which it may be able to increase its reliance on the private sector. In particular, the FAA would like to "eliminate the role of terminal and en route [air traffic controllers] as the conduit of routine weather information to the pilot" (FAA, 1994b). Furthermore, the FAA has indicated that it may elect to withdraw as the primary provider of weather information that is readily available from other sources such as the NWS or the private sector (FAA, 1994a).

Recommendation: *The FAA and NWS should develop more-detailed guidance regarding the future role of private weather services. This guidance should view private weather services as partners in the overall effort to improve the quality and reduce the total cost of aviation weather services.*

As noted in Chapter 3 (page 30), the FAA already funds the private sector to provide computerized preflight weather briefings via DUATS (Direct User Access Terminal Service). In addition, the private sector supports the operation of FSSs (Flight Service Stations) and AFSSs (Automated Flight Service Stations) by supplying information processing and communications system hardware for dissemination of weather information to pilots. Private weather services also sell their weather products for use in FAA and NWS facilities such as FSSs, AFSSs, CWSUs, and Weather Forecast Offices.

If the federal government transfers additional aviation weather services to the private sector, the FAA and NWS should ensure the competency of the private weather services that accept this responsibility. In addition, the committee cautions against establishing new arrangements for providing aviation weather services that would require general aviation pilots to acquire essential preflight weather information on a fee-per-use basis. Although prudent pilots would ensure that they obtain adequate information even if it is only available on a fee-per-use basis, such an arrangement could cause some pilots to cut back on the amount of preflight weather information that they receive. For example, the *Air Traffic Control Corporation Study* concluded that "direct user fees [should] be assessed only in those cases that would not discourage the use of ATC [air traffic control] services," and it recommended that noncommercial aviation be exempt from paying user fees (DOT, 1994). Although this recommendation is focused on air traffic control services, the committee believes that it is equally valid with regard to aviation weather services currently provided by the FAA.

Recommendation: *The federal government should continue to fund aviation weather services that it may transfer to the private sector to ensure that noncommercial general aviation pilots are not confronted by user fees that may discourage the prudent use of aviation weather services.*

DoD

Operationally, the current division of responsibilities among the DoD, FAA, and NWS seems appropriate. The U.S. Air Force and Navy provide aviation weather services to military pilots and air traffic controllers. Although these services generally mirror the services that the NWS and FAA provide to civil aviation, the nature and scope of military operations result in many different operational requirements and systems. Furthermore, the DoD is not structured or equipped to lead a domestic system. Nonetheless, DoD and the NWS share the meteorological data that they collect, and some DoD and NWS systems have been engineered to back-up each other in case of malfunction. The DoD and NWS are also reducing the extent to which they provide duplicate capabilities, especially with regard to high-cost items such as weather satellites.

Because of the DoD's unique worldwide mission, many of its aviation weather research and development programs are focused on specific military requirements that have little relevance to commercial systems. However, the DoD is also involved in the development of new forecasting models, algorithms, display systems, and training programs that may have broader applicability to the aviation weather services that the FAA and NWS provide. Budgetary cutbacks have reduced the scope and extended the schedule of some of these efforts. Closer cooperation among DoD, NOAA, and FAA aviation weather research programs may be able to partially offset the impact of these cuts.

Recommendation: *The DoD should retain primary responsibility within the federal government for providing aviation weather services required by military aviation. The DoD and NWS should continue to coordinate and integrate their meteorological systems.*

NASA

NASA's mission includes fundamental research and technology development activities in aeronautical disciplines to improve the safety and efficiency of the U.S. air transportation system. NASA's mission also includes the provision of technical assistance and facility support to other government agencies and the private sector (see Appendix D, pages 76 and 77). However, as discussed in Chapter 4 (page 44), the FAA does not include NASA in its long-range planning process, and existing interagency coordination mechanisms, such as the FAA-NASA Coordinating Committee, do not provide top-level planning and coordination of research programs conducted by NASA and the FAA.

Recommendation: *NASA should continue to work with the FAd and the private sector to conduct research and technology development activities that will improve aviation safety and efficiency.*

OFCM

The OFCM is intended to function as a catalyst for interagency coordination and cooperation. The OFCM sponsors a total of 40 councils, committees, and working groups, including 3 that are focused on aviation weather activities. These groups, along with OFCM staff, document and assess the federal meteorological program; search for opportunities to improve ongoing and proposed activities; and provide a framework for involved agencies to work together. However, as discussed in Chapter 2 (page 16), the OFCM does not possess the authority to *demand* interagency cooperation or to direct the operational actions of federal agencies. In addition, the OFCM does not have oversight responsibility for *basic* meteorological research by the federal government. As discussed further in Appendix D (page 78), when the OFCM was formed, responsibility for all basic meteorological research and applied meteorological research related to the atmospheric sciences was delegated to another element of the federal government that no longer exists.

With an annual budget of less than $2 million per year, the OFCM does not have the fiscal or personnel resources to assume a significantly expanded role in the provision of aviation weather services or the conduct of related research. The other advisory groups and committees involved in aviation and meteorology face these same limitations. However, as demonstrated by the comprehensive *National Aviation Weather Program Plan* that it issued in 1992, the OFCM does have the resources and capability to evaluate the aviation weather services and related research that the federal government provides. Accordingly, as the FAA exerts stronger leadership in planning and coordinating interagency activities related to aviation weather, the OFCM could assist the FAA and other agencies by periodically assessing the effectiveness of the national aviation weather system and related research. Such assessments should include inputs from a broad range of public and private organizations involved in providing, developing, and using aviation weather services. However, the OFCM should ensure that assessment results are based on objective criteria. The assessments should determine how aviation weather system enhancements could improve aviation safety and efficiency. The assessments should also prioritize proposed and ongoing research and development activities based upon their ability to support deployment of affordable enhancements in a timely fashion.

Recommendation: *The OFCM should periodically assess the effectiveness of the national aviation weather system and related research conducted by the federal government.*

State Governments

Starting in the 1970s, a number of states fielded their own aviation weather observing and pilot briefing systems to augment the systems and services provided by the federal government. State governments have certified weather observers; established automated weather briefing computer terminals (beginning 6 years before the FAA made DUATS available); installed over 400 AWOS (Automated Weather Observing System) units, including the first AWOS unit approved by the NWS and FAA; and pioneered the use of satellite communications to disseminate preflight weather information directly to general aviation pilots. Although state-supported systems do not in all cases fully replicate the level of services that are available from federal systems, the limited amount of information that the committee was able to examine indicates that state systems generally cost less and took less time to acquire than similar federal systems.

Recommendation: *The FAd and NWS should use state aviation weather systems as a resource to improve the overall effectiveness of the national aviation weather system. The FAd and NWS should facilitate actions by interested states to improve local aviation weather systems, especially in regions of the United States, such as Alaska, that have special needs for aviation weather services that regional systems could help address.*

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7

The First Step

Reaffirming and reinforcing the FAA's leadership role is the essential first step to implementing widespread improvements in aviation weather services and related research.

This report contains a variety of recommendations for increasing aviation safety and efficiency by improving the federal government's ability to satisfy the needs of aviation weather users. However, as discussed in Chapter 6, the recommendation for the FAA to assume a strong leadership role is the foundation for all of the committee's other recommendations. This approach may seem simplistic, but it reflects the uncomplicated nature of the key shortcoming in the U.S. aviation weather system. The current system suffers primarily from a lack of coordination and focus. Strong leadership is needed to put in place a vigorous process for evaluating and implementing alternatives for improving the aviation weather system. Without this leadership, recent experience indicates that actions that could dramatically improve the effectiveness of aviation weather services and related research are not likely to take place in a timely fashion, if at all.

MAJOR RECOMMENDATION 9

The federal government should place a high priority on reaffirming and reinforcing the leadership role of the FAd and the supporting roles of other agencies.

Recommendation: *As a first step in improving aviation weather services and related research, the committee suggests the following timeline:*

- *Within 3 months of the release of this report, the FAA should implement the committee's recommendation to designate an associate administrator to assume overall responsibility for carrying out the FAA's lead agency role (see Chapter 6, page 56).*
- *Within 6 months, the executive branch should replace OMB Circular A-62, which has been rescinded without replacement, by issuing "policy guidelines and procedures for planning and conducting Federal meteorological services and applied research and development to improve such services" (OMB Circular A-62; see Chapter 2, page 16, and Appendix D, page 78).*
- *Within 9 months, the FAA and NOAA/NWS should comply with their existing memorandum of agreement regarding the provision of aviation weather services, or they should implement a new agreement (see Chapter 2, pages 16–19).*
- *Within 12 months, with the assistance of the OFCM, the FAd should prepare a definitive 5-year integrated plan specifying the objectives, strategies, schedule, phasing, and budgets needed to achieve an improved aviation weather system. This plan should be developed with inputs from other government agencies and the user community.*

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OMB (Office of Management and Budget) Circular A-62, November 13, 1963.

Appendix A

Summary of Findings and Recommendations

A complete list of the committee's findings and recommendations appears below. This list includes the committee's nine major recommendations, which are numbered and boxed. The other recommendations expand upon and support the major recommendations.

All of the findings and recommendations are listed in the order in which they appear in the body of the report.

CHAPTER 2 CURRENT ROLES AND MISSIONS

Finding: Federal regulations create an implicit responsibility for the Federal Aviation Administration (FAA) to ensure that weather services are available to meet the needs of aviation.

Recommendation: The FAA should view meteorology as a significant component of every area of its responsibility in which weather could affect safety or efficiency.

Recommendation: The FAA should aggressively strive to improve the efficiency of air commerce just as it already strives to improve safety.

Finding: Federal responsibilities for ensuring aviation safety and efficiency and for providing aviation weather services are adequately defined in existing legislation.

Finding: Developing a common understanding of aviation weather requirements between the FAA and National Oceanic and Atmospheric Administration (NOAA) is the critical first step in assessing current aviation weather services and planning improvements.

MAJOR RECOMMENDATION 1

The FAA should aggressively exercise its responsibility for coordinating user needs and expressing requirements for meteorological services to the National Weather Service (NWS).

Recommendation: The FAA and NWS should reestablish the practice of assigning high-level liaisons who are formally tasked with defining and coordinating aviation weather requirements for research, development, and operations between the FAA and NOAA/NWS.

Finding: Routine meetings between FAA and NWS staff could be a valuable tool for improving (1) the practical understanding that aviation forecasters have regarding the needs of air traffic controllers, flight service specialists, and pilots for operational weather information; and (2) the understanding of air traffic controllers and flight service specialists regarding the capabilities, utility, and limitations of aviation weather information.

Recommendation: The FAA and NWS should encourage informal interagency meetings between small groups of staff members at all management levels who are involved in providing or using aviation weather information. In addition, the NWS should enable aviation forecasters to spend duty time routinely in the environments of the aviation weather users that they support.

Finding: The manner in which the federal aviation weather system is managed fosters the development of de facto policies and procedures that limit overall system safety and efficiency.

Recommendation: The Office of Management and Budget (OMB), Department of Transportation, Department of Commerce, and other responsible federal agencies should expeditiously issue *and implement* updated or expanded policy directives to more fully comply with the intent of federal legislation regarding the provision of aviation weather services.

Recommendation: The FAA should examine selected weather-related Federal Aviation Regulations and undertake rulemaking to incorporate appropriate modifications to enhance efficiency as well as safety.

Recommendation: The FAA should assess how proposals to establish a private or federal air traffic services corporation would impact aviation weather services and related research.

Recommendation: The FAA should expeditiously improve aviation weather services rather than delay action while the federal government decides whether to establish an air traffic services corporation to provide some or all of the functions currently provided by the FAA.

CHAPTER 3 CURRENT SERVICES

Recommendation: The NWS should foster the proliferation of official non-federal weather observing sites by establishing one or more additional classifications of surface weather observers, who would be trained and certified to provide partial weather observations.

Recommendation: The FAA should ensure that long-term operational funding is provided for the Meteorological Data Collection and Reporting System (MDCRS). In addition, the FAA should enhance the value of MDCRS by encouraging more air carriers to participate in the program.

Recommendation: The FAA and NWS should continue to resolve user-identified issues associated with the Automated Surface Observing System (ASOS) and use the lessons learned from the ASOS acquisition to improve the process by which new systems are conceived, developed, and deployed.

Recommendation: The FAA and NOAA should maximize the payoff of national investments in new weather observing systems by implementing improved information processing systems and new data analysis tools such as the Aviation Gridded Forecast System.

Recommendation: The FAA and NWS should develop a procedure to designate private weather services as approved sources of specific aviation weather products.

Recommendation: The NWS should continue ongoing efforts to increase the availability and accuracy of short-term forecasts and nowcasts.

Recommendation: The NWS should continue ongoing efforts to increase the accuracy, timeliness, and geographic resolution of en route and terminal forecasts, especially with regard to icing and turbulence.

Recommendation: The FAA and NWS should develop a process to allow pilots and other users of airport terminal forecasts to provide timely feedback to the NWS forecasters who generate these forecasts.

Recommendation: The FAA should implement an improved Direct User Access Terminal Service (DUATS) that (1) makes it easier for pilots to understand what weather conditions are likely to impact their specific flights, (2) improves user access to graphic weather products (perhaps by using communications systems such as the Internet), and (3) improves the efficiency of pilot weather briefings by flight service specialists.

Recommendation: Flight service specialists should remain available as a source of preflight and en route weather information for general aviation and business pilots.

Recommendation: The FAA should take the lead in developing tailored and consistent graphic aviation weather products that feature improved accuracy, timeliness, and resolution.

Finding: The limited capabilities of existing cockpit display and ground-to-air communications systems are the largest technical impediments to improving dissemination of graphic weather information to pilots en route.

Recommendation: The FAA should support ongoing work that addresses shortcomings in cockpit display and ground-to-air communications systems. The FAA should also continue to provide voice radio links to weather briefers on the ground, such as those currently provided by AFSSs, until a practical alternative system is fielded.

Finding: Increasing the ability of air traffic controllers to access accurate weather information would encourage them to monitor meteorological conditions routinely. Increasing controllers' awareness of adverse weather could significantly contribute to the safety and efficiency of the airways.

Recommendation: The FAA and NWS should improve the effectiveness of Center Weather Service Units (CWSUs) by taking the following actions:

- The NWS should place all 21 CWSUs under the organizational authority of the Aviation Weather Center that the NWS is establishing in place of the National Aviation Weather Advisory Unit.
- The FAA should challenge CWSUs to improve the level of services that they provide. In particular, the FAA should encourage managers and staff at Air Route Traffic Control Centers to use the full capabilities of the CWSUs, and it should ensure that en route air traffic controllers receive preshift weather briefings from CWSU meteorologists.

Recommendation: The FAA should facilitate the ability of airport operators to acquire appropriate weather information by granting their operational staff routine access to DUATS.

Recommendation: The FAA should take the following actions to improve weather-related training:

- Encourage universities, flight schools, and other training facilities to focus initial and recurrent training of aviation weather users and providers on understanding and optimizing the use of available weather information.
- Revise federal licensing procedures for pilots, controllers, flight service specialists, and dispatchers to

test more effectively the abilities of candidates to use weather information in making safe operational decisions regarding the weather.

- Increase the emphasis that weather receives during biennial flight reviews, safety seminars, and refresher courses for designated pilot examiners and flight instructors.

MAJOR RECOMMENDATION 2

The FAA should provide the leadership needed to develop a comprehensive national training program that improves the practical meteorological skills of users and providers of aviation weather services.

Recommendation: The FAA should take the lead in establishing and aggressively pursuing aviation weather goals and priorities that reflect the positions of other involved parties, including the following:

- other federal agencies and departments;
- other providers of aviation weather services (e.g., private weather services and state governments); and
- user groups, including the unions, associations, and industry groups that represent those who work with the U.S. aviation weather system on a daily basis: air carrier personnel, pilots, air traffic controllers, flight service specialists, meteorologists, and dispatchers.

Recommendation: Near-term efforts by the FAA and NWS to improve the effectiveness of aviation weather services should focus on the urgent, unmet needs of aviation weather users, which include the following:

- a comprehensive national training program to improve the practical meteorological skills of users and providers of aviation weather services;
- advanced weather products that are relevant, timely, accurate, and easy to comprehend (e.g., graphically displayed);
- ground-to-air communications and cockpit display systems for en route dissemination of advanced weather products; and
- weather observations and forecasts that offer improved temporal, geographic, and altitude-specific resolution.

MAJOR RECOMMENDATION 3

The FAA should swiftly exploit current technology to provide consistent and timely graphic weather information to pilots, controllers, and dispatchers.

CHAPTER 4 RESEARCH AND DEVELOPMENT

Finding: It is the proper role of government to develop, fund, and execute a research plan in aviation weather just as it does in many other areas involving the public good.

Recommendation: The federal government should make a long-term commitment to aviation weather research as an investment in the future safety and efficiency of aviation.

Recommendation: The FAA should take the lead in implementing the recommendation of the Office of the Federal Coordinator for Meteorology (OFCM) to develop an interagency plan for aviation weather research and development.

Recommendation: The FAA should augment its meteorological expertise to enhance its ability to plan and implement effective aviation weather services.

Recommendation: The FAA and Congress should maximize the effectiveness of new aviation weather systems by ensuring that related research, training, system installation, and support systems are funded with a priority equal to that of the system acquisition efforts with which they are associated.

Finding: The FAA is in the best position to provide the leadership, establish the priorities, and advocate the funding required to develop an aviation weather system that meets national needs.

Recommendation: The following steps should be taken to improve aviation weather research and development processes:

- The FAA, NOAA/NWS, National Science Foundation, National Aeronautics and Space Administration (NASA), and Department of Defense (DoD) should collaborate under FAA leadership to develop, fund, and implement a comprehensive plan for aviation weather research and development with firm objectives and closely integrated program plans and funding commitments. The OFCM should facilitate the development of such a plan, but final commitments should be made by agency heads.
- The meteorological expertise needed to develop and implement the plan described above could come primarily from NOAA and DoD. However, it would also be prudent to strengthen the FAA's in-house meteorological expertise.
- The FAA and NOAA should ensure that aviation weather research and development are closely coupled to operational components of these agencies so

that new concepts and new ideas can be swiftly integrated into ongoing operations.

- The aviation weather research and development process should seek continuing and in-depth involvement with all users, especially the pilots, controllers, forecasters, and dispatchers who depend on weather information to facilitate safe and efficient operations.

MAJOR RECOMMENDATION 4

The FAA should provide the leadership needed to support and focus research and development efforts by government, academic, and industrial institutions on key aviation weather issues.

CHAPTER 5 REGIONAL REQUIREMENTS

Finding: VFR (visual flight rules) aviation in Alaska plays a role of uniquely vital economic and social significance. However, the safety and efficiency of aviation in Alaska is limited by deficiencies in the aviation weather system that have persisted for at least the last 15 years.

Recommendation: The FAA, on behalf of the federal government, should take the lead in finding the means to meet special regional needs for aviation weather services. In regions that have special needs, the FAA should establish a team that includes other responsible federal and state government agencies, the local aviation industry, airport operators, pilots, professional organizations, and local communities to identify, assess, and properly respond to these needs. Such a team should address the following areas:

- The overall aviation weather goals and priorities of the local user community and how they differ from those that drive the national aviation weather system.
- The role that each of the involved parties should play in meeting these goals.
- The extent to which it is practical to modify the structure and processes of the national aviation weather system to accommodate special needs of local users. There should be an appropriate balance between the competing goals of (1) maximizing the effectiveness of the regional system, which might call for highly customized services, and (2) minimizing regional variances in the national system so that users are not confused by differing procedures as they travel throughout the country.
- The optimum methods for allocating available resources. Existing aviation weather systems would clearly benefit from the allocation of more resources, and it may be appropriate for federal and state agencies to request that their future budgets contain additional funds. First, however, it is imperative to determine if service can be improved by reallocating currently available resources.

After addressing the above areas, the FAA should take the lead in assuring that appropriate action is taken. The FAA should also initiate appropriate statutory and regulatory variances to accommodate the agreed-upon plan of action.

Recommendation: State governments should play a role in responding to special regional needs for aviation weather services that is second only to that of the federal government.

MAJOR RECOMMENDATION 5

The FAA should provide the leadership to meet regional needs for aviation weather services with regional solutions.

CHAPTER 6 FUTURE ROLES AND MISSIONS

Recommendation: As part of its effort to provide necessary leadership, the FAA should accomplish the following tasks:

- Specify national and regional aviation weather requirements.
- Organize multiagency participation in aviation weather research, operations, and training.
- Justify aviation weather budget requests.
- Orchestrate a coordinated aviation weather research and development program.
- Improve the understanding and use of weather information by aviation users.
- Provide day-to-day dissemination of weather information to aviation users.
- Respond to the other recommendations contained in this report and in *Weather for Those Who Fly* (NRC, 1994).

MAJOR RECOMMENDATION 6: THE PRIMARY RECOMMENDATION

The FAA should provide the leadership, establish the priorities, and ensure the funding needed to improve weather services for aviation users and to strengthen related research.

Recommendation: The executive branch should formally designate the FAA as the lead federal agency for ensuring the effectiveness and efficiency of the national aviation weather system.

Recommendation: The FAA should seek a broad consensus on aviation weather goals and priorities with (1) other federal agencies; (2) other providers of aviation weather services (i.e., private weather services and state governments); (3) research organizations; and (4) user groups, including the unions, associations, and industry groups that represent those who work with the U.S. aviation weather system on a daily basis: air carrier personnel, pilots, air traffic controllers, flight service specialists, meteorologists, and dispatchers.

Recommendation: The FAA Administrator should designate an associate administrator to assume overall responsibility for carrying out the FAA's lead agency role for aviation weather and to serve as a single focal point within the FAA with the authority to provide effective internal and external coordination of aviation weather services and related research programs that involve the FAA.

MAJOR RECOMMENDATION 7

The FAA should adopt the philosophy that weather services are an important part of its air traffic responsibilities; it should develop procedures and weather products to improve the ability of pilots and air traffic controllers to ensure that aircraft avoid hazardous weather.

MAJOR RECOMMENDATION 8

The NWS should continue to meet FAd-determined requirements for weather services as part of its responsibilities for atmospheric observations, analyses, and forecasts.

Recommendation: The Aviation Weather Center should be established with expanded authority to oversee aviation weather services within the NWS. At a minimum, this should include oversight of the NWS's 21 CWSUs. The NWS should also explore other options for using the Aviation Weather Center's specialized capabilities.

Recommendation: The FAA and NWS should develop more-detailed guidance regarding the future role of private weather services. This guidance should view private weather services as partners in the overall effort to improve the quality and reduce the total cost of aviation weather services.

Recommendation: The federal government should continue to fund aviation weather services that it may transfer to the private sector to ensure that noncommercial general aviation pilots are not confronted by user fees that may discourage the prudent use of aviation weather services.

Recommendation: The DoD should retain primary responsibility within the federal government for providing aviation weather services required by military aviation. The DoD and NWS should continue to coordinate and integrate their meteorological systems.

Recommendation: NASA should continue to work with the FAA and the private sector to conduct research and technology development activities that will improve aviation safety and efficiency.

Recommendation: The OFCM should periodically assess the effectiveness of the national aviation weather system and related research conducted by the federal government.

Recommendation: The FAA and NWS should use state aviation weather systems as a resource to improve the overall effectiveness of the national aviation weather system. The FAA and NWS should facilitate actions by interested states to improve local aviation weather systems, especially in regions of the United States, such as Alaska, that have special needs for aviation weather services that regional systems could help address.

CHAPTER 7 THE FIRST STEP

MAJOR RECOMMENDATION 9

The federal government should place a high priority on reaffirming and reinforcing the leadership role of the FAA and the supporting roles of other agencies.

Recommendation: As a first step in improving aviation weather services and related research, the committee suggests the following timeline:

- Within 3 months of the release of this report, the FAA should implement the committee's recommendation to designate an associate administrator to assume overall responsibility for carrying out the FAA's lead agency role (see Chapter 6, page 56).
- Within 6 months, the executive branch should replace OMB Circular A-62, which has been rescinded without replacement, by issuing "policy guidelines and procedures for planning and conducting Federal meteorological services and applied research and development to improve such services" (OMB Circular A-62; see Chapter 2, page 16, and Appendix D, page 78).
- Within 9 months, the FAA and NOAA/NWS should comply with their existing memorandum of agreement regarding the provision of aviation weather services, or they should implement a new agreement (see Chapter 2, pages 16–19).
- Within 12 months, with the assistance of the OFCM, the FAA should prepare a definitive 5-year integrated plan specifying the objectives, strategies, schedule, phasing, and budgets needed to achieve an improved aviation weather system. This plan should be developed with inputs from other government agencies and the user community.

REFERENCES

NRC (National Research Council). 1994. Weather for Those Who Fly. National Weather Service Modernization Committee, National Research Council. Washington, D.C.: National Academy Press.

OMB (Office of Management and Budget) Circular A-62, November 13, 1963.

Appendix B

Biographical Sketches of Committee Members

Brig Gen Albert J. Kaehn, Jr., USAF (retired), *Chairman*, is currently a consultant for management, business-development, and weather-system matters. He recently retired from Harris Corporation, where he was a director of business development and advanced programs. Previously, he completed 30 years of service with the U.S. Air Force in 1982, retiring as Commander of the Air Weather Service, where he was responsible for worldwide weather and space environmental support to the Air Force, U.S. Army, and designated defense agencies. Earlier in his career, he also commanded a squadron in Southeast Asia, served as the military assistant for environmental sciences in the Office of the Secretary of Defense, and commanded a weather wing supporting the Strategic Air Command. Brig Gen Kaehn is a Fellow of the American Meteorological Society, having served as its president in 1987.

Dr. John A. Dutton, *Vice Chairman*, is Professor of Meteorology and Dean of the College of Earth and Mineral Sciences at the Pennsylvania State University. He is also president of the University Corporation for Atmospheric Research Foundation. Dr. Dutton was a member of the NASA Space and Earth Sciences Advisory Committee and the Earth System Sciences Committee. He serves on several committees of the National Research Council. Dr. Dutton holds three degrees in meteorology from the University of Wisconsin and served as an officer in the Air Weather Service of the U.S. Air Force. He is a fellow of the American Meteorological Society and the American Association for the Advancement of Science. He is the author of two textbooks in atmospheric science and a variety of articles on the dynamics of atmospheric motion. Dr. Dutton is an active general aviation pilot with multiengine and instrument ratings.

Col Grant C. Aufderhaar, USAF (retired), *Research and Development Panel Leader,* is currently a Senior Engineer for the Aerospace Corporation, a non-profit corporation that operates a federally funded research and development center. He is the former Assistant for Environmental Sciences in the Office of the Secretary of Defense, where he had oversight of environmental programs within the Department of Defense (DoD) and represented the DoD in interagency fora on environmental matters. He had responsible positions at the Pentagon with the Chief of Staff of the Air Force, and he was Chief Meteorologist to the Air Force's Aeronautical Systems Center, where he was responsible for environmental input to the research, development, test, and acquisition of Air Force aircraft programs.

Maj Gen William W. Hoover, USAF (retired), *Operations Panel Leader,* is currently a consultant for aviation, defense, and energy matters. He is the former Executive Vice President of the Air Transport Association, where he represented the interests of major U.S. airlines, particularly with regard to technical and safety issues. He previously served as the Assistant Secretary, Defense Programs, U.S. Department of Energy, where he was responsible for the U.S. nuclear weapons program. Within the Air Force, he had responsible positions at the Pentagon with the Secretary of the Air Force and North Atlantic Treaty Organization. He also commanded a combat wing and flew as a fighter pilot in Vietnam.

Dr. Sue Ann Bowling has worked with the Geophysical Institute of the University of Alaska for 25 years. Dr. Bowling currently serves as an assistant professor, and she is involved in the study of local meteorological variations, climatological change, the Alaskan climate, and paleoclimatology. She has also participated in studies at the National Center for Atmospheric Research.

Dr. George P. Cressman served as the director of the National Weather Service during 1965–1979. Previously, he served as a director of the National Meteorological Center, a director of the Navy-Air Force Numerical Weather Prediction Unit, and a commissioned officer in the United States Army. Dr. Cressman is a Fellow of the American Meteorological Society.

Mr. Wilfred A. "Bill" Jackson spent 26 years in the U.S. Army as a commissioned officer and rated Army aviator. Mr. Jackson was subsequently employed by the BDM Corporation and the MITRE Corporation in the areas of training and airborne communications. He later served as the Director of Operations at the Baltimore/Washington International Airport. Mr. Jackson was instrumental in the design, installation, and operation of the first computer controlled security access system at an airport. Following his airport tenure, he joined the staff of the Airports Council International-North America as the Director of Security and Environmental Affairs. Currently he is an assistant professor at the University of North Dakota Center for Aerospace Sciences where he teaches aviation management. He is also involved in several areas of research, focusing on airport management and operating issues. He is an accredited airport executive with the American Association of Airport Executives. Mr. Jackson has served on several boards and committees, including the Executive Board of the National Aerospace Foreign Object Debris/Damage Conference, the Aviation Security Advisory Committee, the Advisory Panel of the Office of Technology Assessment, and several committees of the National Research Council.

Mr. Carl R. Knable is currently Manager of Meteorology for United Airlines, a position he has held since 1976. He has been active in the field of aviation meteorology for his entire career: 27 years with United Airlines and 4 years as a U.S. Air Force weather officer supporting Strategic Air Command operations. He has served several terms as chairman of the Air Transport Association Meteorology Committee, which represents the weather interests of the major U.S. airlines.

Mr. Peter R. Leavitt, a certified consulting meteorologist, is Chairman and Chief Executive Officer of Weather Services Corporation. As a founder and past President of WSI Corporation, he was responsible for the development of one of the first on-line, real-time meteorological databases. As a principal of Weather Services Corporation, he directed the development of WSC's agricultural and commodity services and its international weather services. He is a recognized authority on agricultural weather and its effect on crops. Mr. Leavitt chaired the American Meteorological Society's Committee on Fellows, and he has served on several other committees of the American Meteorological Society, including the Board of Applied Climatology, the Board of Human Resources, and the Board of Admissions. He is a former President of the National Council of Industrial Meteorologists and a Charter Member and former Councilor of the National Weather Association. He has served on the National Research Council's Committee on the Modernization of the National Weather Service and is currently chairman of the National Weather Service's Modernization Transition Committee.

Mr. Robert J. Massey is chairman of the Air Line Pilots Association's Aviation Weather Committee. He has over 15 years of commercial aviation experience (both domestic and international), and 20 years of military transport flight operations. He has participated in several accident investigations by the National Transportation Safety Board on behalf of the Air Line Pilots Association, and he organized and co-chaired the first joint civilian/military conference on weather training for professional pilots.

Mr. Paul K. Rosenwald, a principal engineer for NYMA, Inc., currently provides technical and engineering support for the development of automated surface observation systems. He has extensive experience in the design and development of communications, flight service, and weather detection systems for the Federal Aviation Administration (FAA). During his 35-year career with the FAA, he served as both program manager and branch manager in the Air Traffic Plans and Requirements Service. He is a former air traffic controller and a certified weather briefer and weather observer.

Dr. Wayne R. Sand owns an aviation weather consulting business based in Boulder, Colorado. He has been an active pilot since 1959 and is currently a general aviation aircraft owner, using his aircraft in his business. He is a former Navy pilot with experience flying combat jet aircraft from carriers in Vietnam and the Mediterranean. He has extensive flight experience as both a pilot and scientist, using weather-research aircraft to make detailed atmospheric measurements in all types of weather throughout the United States. He has also managed corporate flight departments that have transported personnel throughout the United States. Prior to starting his own business, he was Deputy Director of the Research Applications Program at the National Center for Atmospheric Research. His division was active in the development of aviation weather technology for the FAA.

Dr. David N. Schramm is the Louis Block Professor in the Physical Sciences at the University of Chicago. He is a theoretical astrophysicist, with over 300 scientific publications, and the recipient of numerous professional awards. He is a member of the National Academy of Sciences and the American Academy of Arts and Science, and he is currently the chairman of the National Research Council's Board on Physics and Astronomy. He is also on the Board of Overseers of the Fermi National Accelerator Lab, is Chairman of the Board of the Aspen Center for

Physics, and consults at Lawrence Livermore and Los Alamos National Laboratories. He is an active general aviation pilot with an airline transport pilot rating and operates a twin turboprop aircraft under the name of Big Bang Aviation, Inc.

Mr. Paul H. Smith is the Senior Manager of Air Traffic Services for the National Business Aircraft Association. In this capacity, he deals with corporate and business aviation issues in the areas of airspace management, air traffic management, aviation weather, aircraft accident investigations, and aviation training. Mr. Smith is a dualrated airline transport pilot and holds a certified instructor certificate with gold seal, a senior air traffic rating, and an advanced ground instructor rating. Previously, Mr. Smith worked as a military air traffic control tower chief, flight standardization and training officer, and aviation safety engineer. He serves on several University Aviation Safety Advisory Boards and is a past chairman of the Air Traffic Procedures Advisory Committee. His aviation industry experience spans 32 years and has focused on safety, training, and excellence in the aviation environment.

Mr. Thomas H. Wardleigh is Chairman oft he Board of Directors of the Alaska Aviation Safety Foundation, a nonprofit corporation dedicated to preventing aviation accidents. He is an airline transport pilot with 31,000 hours in civilian airplanes, including extensive multiengine, seaplane, and ski-flying experience in the Arctic. Mr. Wardleigh retired after 35 years of federal service as a pilot with the U.S. Department of Interior and the FAA. He contributed to the initial establishment of many instrument airways and terminal approach procedures in Alaska. The FAA awarded Mr. Wardleigh the Charles Taylor Award for 50 years of continuous service as a certified aviation and powerplant mechanic, and the Aircraft Owners and Pilots Association honored him with the Lawrence P. Sharples award for leadership in civilian aviation safety. He is an active flight instructor, mechanic, and aviation consultant.

Appendix C

Participants in Committee Meetings

The committee acknowledges the assistance that the following organizations and individuals provided during meetings with committee members and staff:

AAI Systems Management, Inc.: John Lasley
Aircraft Owners and Pilots Association: Phil Boyer, Steve Brown, Doug Helton
Air Traffic Control Association: James Cook
Air Transport Association: Jack Ryan, William Sears
Alascorn: Felix Maguire
Alaska Air Carriers Association: Richard Harding, Kurt Harris
Alaska Airlines: Theron Smith, Terry Smith
Alaska Airmen's Association: Phil Livingston
Alaska Air National Guard: Vic Evans, Robert C. Gastrock, Al Lupenski, Jack Scroggs
Alaska Aviation Safety Foundation: Virginia Hyatt
Alaska Department of Transportation: Helvi Sandvik, Ron Samsal, Carl Siebe, Jon Widdis
American Airlines: Warren Qualley, D. E. Kneram
Anchorage International Airport: N. Wayne Gibson
Aviation Management Associates, Inc.: Gary Church
Atlantic Richfield: Bill Overway
BDM, Inc.: Robin Deyoe
Denton & Associates: Lawrence Denton
Department of Defense: Bradley Smith
Federal Aviation Administration (Air Route Traffic Control Center, Anchorage): Joseph Rollins, Duane McQuillion
Federal Aviation Administration (Air Traffic Control System Command Center): Chester Smerdzinski
Federal Aviation Administration (Air Traffic Control Tower, Dulles): William Carver, Ester Kontos
Federal Aviation Administration (Automated Flight Service Station, Leesburg): Dmitri Suk
Federal Aviation Administration (Former Administrators): James Busey IV, Donald Engen, Najeeb Halaby
Federal Aviation Administration (Headquarters): Monte Belger, Anthony Broderick, George Donohue, Craig Goff, Richard Heuwinkel, Bill Jeffers, Paula Lewis, Carl McCullough, Geoffrey Mcintyre, Ron Morgan, Martin Pozesky, Robert Valone, Steve Zaidman
Federal Aviation Administration (Regional Office, Kansas City): John Turner, Wanda Munoz
Federal Aviation Administration (Terminal Radar Approach Control, Denver): Paul Cazziniggi
Forecast Systems Laboratory: Stan Benjamin, Richard Jesuroga, Michael Kraus, John McGinley, Patricia Miller, Lynn Scherretz, Thomas Schlatter
GTE Government Systems: Leon Thomas
General Accounting Office: Randy Hite
Harris Corporation: Bryce Ford, Donald Jones
Kavouras, Inc.: Steve Madsen
Ketchurn Air Service: Craig Ketchurn
Mark Air: Steve Cherwien
MIT Lincoln Laboratory: James Evans, Steve Campbell
MITRE Corporation: Russell Benel, John Fearnsides, Joseph Matney, Jeff Mittleman, Anand Mundra, Again Sinha
National Academy of Engineering: Robert White
National Aeronautics and Space Administration: Herbert Schlickenmaier
National Air Traffic Controllers Association: William Faville Jr., Jerry Tierney
National Association of Air Traffic Specialists: Mike McAnaw
National Center for Atmospheric Research: G. Brante Foote, Dale Kellogg, Robert Serafin, Tim Spangler
National Oceanic and Atmospheric Administration (Headquarters): James Baker, Diana Josephson
National Research Council (National Weather Service Modernization Committee): Floyd Hauth
National Science Foundation: Kenneth Van Sickle National Transportation Safety Board: John Lauber, Jim Danaher, Greg Salottolo, James Skeen
National Weather Service (National Severe Storms Forecast Center): Frederick Ostby, James Henderson, Ron Olson, Fred Moser
National Weather Service (Center Weather Service Unit, Anchorage): Paul McCloud

National Weather Service (Center Weather Service Unit, Chicago): Allan Fisher
National Weather Service (Center Weather Service Unit, Denver): Jonette Williams, Fred Foss
National Weather Service (Center Weather Service Unit, Leesburg): Rocky Burke, Norbert Novocin
National Weather Service (Central Flow Weather Service Unit, Herndon): Steve Henderson
National Weather Service (Flight Service Station, Dillingham): Frank Azzaro
National Weather Service (Headquarters): Dorothy Becker, Elbert Friday Jr., Charles Sprinkle, Michael Tomlinson, Louis Uccellini, Susan Zevin
National Weather Service National Meteorological Center): Geoff DiMego
National Weather Service (Regional Office, Anchorage): H. Lee Kelley Jr., James Kemper
National Weather Service (Regional Office, Kansas City): Richard Augulis, Jack May
National Weather Service Training Center: Joe Schaefer
National Weather Service (Weather Forecast Office, Denver): David Imy
National Weather Service (Weather Forecast Office, Sterling): Gary Szatkowski, Steve Zubrick
National Weather Service (Weather Station, Barrow): C. O. Evans
Office of the Federal Coordinator for Meteorology: Julian Wright, Jr., Donald Carver
Office of Management and Budget: Jeff Payne, Jee Rhee
Office of Technology Assessment: Kelley Scott
Peninsula Airlines: Ginny Seybert, Orin Seybert
Regional Airline Association: Walter Coleman
United Air Lines: Jesse Marker, Kent Parsons, Joseph Raulins
University Corporation for Atmospheric Research: John McCarthy
U.S. Air Force: Willis Shanor, Gerard Wittman
U.S. House of Representatives (Staff): Dennis Achgill, Richard Efford, Curtis Stanford
U.S. Navy: Michael Dotson, Christopher Gallagher, Charles Hopkins, Fred Klein
U.S. Senate (Staff): Jeff Goldstein
Weather Services Corporation: Mike Leavitt
Wings Alaska: Robert Jacobson
WSI Corporation: Arlo Gambell
Yute Airways: Mike Anderson, Steve Huddleston, Scott Schwitzer

Appendix D

Reference Documents for Current Roles and Missions

Federal roles and missions for aviation weather services and related research are divided among the Federal Aviation Administration (FAA), National Oceanic and Atmospheric Administration/National Weather Service (NOAA/NWS), Office of the Federal Coordinator for Meteorology (OFCM), and the National Aeronautics and Space Administration (NASA) in accordance with the following key documents:

- Organic Act of 1890, as amended and incorporated into Title 15 of the U.S. Code of Federal Regulations;
- Weather Services Modernization Act, Public Law 102–567, Title VII, October 1992;
- Federal Aviation Act of 1958, as amended and incorporated into Title 49 of the U.S. Code of Federal Regulations;
- National Aeronautics and Space Act of 1958, as amended and incorporated into Title 42 of the U.S. Code of Federal Regulations;
- Department of Commerce Appropriations Act of 1963, as incorporated in Title 68 of the U.S. Code of Federal Regulations;
- OMB Circular A-62, November 13, 1963, and Department of Commerce Implementation Plan for Circular A-62, January 9, 1964; and
- Memorandum of Agreement Between the FAA and the NOAA for the Establishment of Working Arrangements for Providing Aviation Weather Service and Meteorological Communications, January 24, 1977.

This appendix summarizes each of these documents.

ORGANIC ACT OF 1890

The Organic Act of 1890 established a civilian organization—the Weather Bureau—to provide federal weather services. Prior to this act, weather services had been provided primarily by the Signal Corps of the U.S. Army. This act, as subsequently amended, remains in effect as part of Title 15 of the U.S. Code of Federal Regulations.

Sections 311 and 313 of Title 15 place the NWS within the Department of Commerce and make the Secretary of Commerce responsible for making meteorological observations, forecasting weather, and issuing storm warnings.

Section 313a of Title 15 directs the Secretary of Commerce to develop "an international basic meteorological reporting network in the Arctic region of the Western Hemisphere, including the establishment, operation, and maintenance of such reporting stations," to "improve the weather forecasting service.., and promote safety and efficiency in civil air navigation to the highest degree."

WEATHER SERVICES MODERNIZATION ACT

As noted in *Toward a New National Weather Service—Review of Modernization Criteria* (NRC, 1993), the U.S. Congress has demonstrated considerable interest in the NWS Modernization Program, which involves closing or relocating many local weather offices. One manifestation of this interest is the Weather Services Modernization Act (Title VII of Public Law 102–567) by which Congress requires the Secretary of Commerce to certify that the modernization process will not degrade local weather services.

Sec. 705, Changes in Field Office Operations

(b) Weather Radar Decommissioning. The Secretary [of Commerce] shall not remove or permanently decommission any National Weather Service radar until the Secretary has prepared radar commissioning and decommissioning reports documenting that such action would be consistent with the modernization criteria established under section 704(b)(1). The commissioning report shall document that the radar system performs reliably, satisfactory maintenance support is in place, sufficient staff with adequate training are present to operate the system, technical coordination with weather service users has been completed, and the radar being commissioned satisfactorily supports field office operations. The decommissioning report shall document that the replacement radar has been commissioned, technical coordination with service users has been completed, and the radar being decommissioned is no longer needed to support field office operations.

(c) Surface Observing System Commissioning. The Secretary may not commission an automated surface observing system located at an airport unless it is determined, in consultation with the Secretary of Transportation, that the weather services provided after commissioning will continue to be in full compliance with applicable flight aviation rules promulgated by the Federal Aviation Administration.

Sec. 706, Restructuring Field Offices

(b) Certification. The Secretary [of Commerce] shall not close, consolidate, automate, or relocate any field office, unless the Secretary has certified that such action will not result in any degradation of service.

(e) Special Circumstances. The Secretary may not close or relocate any field office—

(1) which is located at an airport, unless the Secretary, in consultation with the Secretary of Transportation and the [Modernization Transition] Committee, first conducts an air safety appraisal, determines that such action will not result in degradation of service that affects aircraft safety, and includes such determination in the certification required under subsection (b); or

(2) which is the only office in a State, unless the Secretary first evaluates the effect on weather services provided to in-state users, such as State agencies, civil defense officials, and local public safety offices, and includes in the certification required under subsection (b) the Secretary's determination that a comparable level of weather services provided to such in-State users will remain.

(f) Liaison Officer. The Secretary may not close, consolidate, automate, or relocate a field office until arrangements have been made to maintain for a period of at least 2 years at least one person in the service area to act as a liaison officer who—

(1) provides timely information regarding the activities of the National Weather Service which may affect service to the community, including modernization and restructuring; and

(2) works with area weather service users, including persons associated with general aviation, civil defense, emergency preparedness, and the news media, with respect to the provision of timely weather warnings and forecasts.

FEDERAL AVIATION ACT OF 1958, AS AMENDED

The Federal Aviation Act of 1958, which has been incorporated into Title 49 of the U.S. Code of Federal Regulations, is the primary legislative reference governing domestic civil aviation. This act is continually revised and, as a result, it remains current. The act's overall goals, which have remained constant, are as follows:

- "... to provide for the regulation and promotion of civil aviation in such a manner as to best foster its development and safety, and
- to provide for the safe and efficient use of the airspace by both civil and military aircraft, and for other purposes."

Sections 304, 305, 307, 310, 312, and 803 of the act, as amended, are of particular importance to the provision of aviation weather services and the conduct of related research.

Section 304, Authority of the President to Transfer Certain Functions

The President may transfer to the Administrator any functions ... of the executive departments or agencies ... which relate primarily to selecting, developing, testing, evaluating, establishing, operating and maintaining systems, procedures, facilities, or devices for safe and efficient air navigation and air traffic control. In connection with any such transfer, the President may pro vide for appropriate transfers of records, property, and ... personnel.

Section 305, Fostering of Air Commerce

The Administrator is empowered and directed to encourage and foster the development of civil aeronautics and air commerce in the United States and abroad.

Section 307, Airspace Control and Facilities

The Administrator is authorized and directed to develop plans for and formulate policy ... to insure the safety of aircraft and the efficient utilization of [the navigable] airspace.... The Administrator is further authorized and directed to prescribe air traffic rules ... for the navigation, protection, and identification of aircraft ... and ... for the prevention of collision between aircraft....

Section 310, Meteorological Service

The Administrator is empowered and directed to make recommendations to the Secretary of Commerce for providing meteorological service necessary for the safe and efficient movement of aircraft in air commerce. In providing meteorological services, the Secretary of Commerce shall cooperate with the Administrator and give full consideration to such recommendations.

Section 312, Development Planning

The Administrator is directed to make long range plans for and formulate policy with respect to the orderly development of and use of the navigable airspace.... The Administrator shall develop, modify, test, and evaluate systems, procedures, facilities, and devices ... to meet the needs for safe and efficient navigation and traffic control.... The Administrator shall undertake or supervise research ... to enhance air traffic controller ... and flight crew performance.... [Section 44505(c) of Title 49 further specifies that "the Administrator shall conduct or supervise research on ... aviation issues related to developing and maintaining a safe and efficient air transportation system."]

Section 803, Weather Service

In order to promote safety and efficiency in air navigation to the highest possible degree, the Secretary of Commerce shall, in addition to any other functions or duties pertaining to weather information for other purposes,

1. make such observations, measurements, investigations, and studies of atmospheric phenomena, and establish such meteorological offices and stations, as are necessary or best suited for ascertaining, in advance, information concerning probable weather conditions;
2. furnish such reports, forecasts, warnings, and advices [sic] to the Secretary of Transportation and to such persons engaged in civil aeronautics ... in such manner and with such frequency as will best result in safety in and in facilitating air navigation;
3. cooperate with persons engaged in air commerce ... and collect and disseminate weather reports available from aircraft in flight;
4. establish and coordinate the international exchanges of meteorological information required for the safety and efficiency of air navigation;
5. participate in the development of an international basic meteorological reporting network, including the establishment, operation, and maintenance of reporting stations ... in polar regions ... in cooperation with ... persons engaged in air commerce;
6. coordinate meteorological requirements in the United States in order to ... avoid duplication of services unless such duplication tends to promote the safety and efficiency of air navigation; and
7. promote and develop meteorological science and ... research projects....

NATIONAL AERONAUTICS AND SPACE ACT OF 1958, AS AMENDED

The National Aeronautics and Space Act of 1958, which has been incorporated into Title 42 of the U.S. Code of Federal Regulations, is the primary legislative reference governing civil aeronautics and space research. Like the Federal Aviation Act of 1958, this act has been continually revised and remains current.

Sections 2451, Subsection 101, National Aeronautics and Space Capital Development Program

Congress finds that—

(18) the goal of aeronautical research and technology development and validation activities should be to contribute to a national technology base that will enhance United States preeminence in civil and military aviation and improve the safety and efficiency of the United States air transportation system; and

(19) aeronautical research and technology development and validation activities should—

(A) emphasize emerging technologies with potential for breakthrough advances;

(B) consist of—

(i) fundamental research in all aeronautical disciplines, aimed at greater understanding of aeronautical phenomena and development of new aeronautical concepts; and

(ii) technology development and validation activities aimed at laboratory-scale development and proof-of-concept demonstration of selected concepts with high payoff potential; ...

(E) include providing technical assistance and facility support to other government agencies and United States industry;

(F) include conducting joint projects with other government agencies where such projects contribute materially to the goals set forth in this section; ....

Section 2451, Subsection 305, Aeronautical Research and Technology Development and Validation Long Range Plan

The [NASA] Administrator should develop a plan in pursuit of—

(1) a vigorous program in aeronautics research and technology development and validation, emphasizing emerging technologies with the potential for breakthrough advances to enhance United States preeminence in civil and military aviation."

Section 2473, Functions of Administration

(a) The [National Aeronautics and Space] Administration, in order to carry out the purpose of this chapter, shall—

(1) plan, direct, and conduct aeronautical and space activities;

(3) provide for the widest practicable and appropriate dissemination of information concerning its activities and the results thereof.

(c) In the performance of its functions the [National Aeronautics and Space] Administration is authorized—

(6) to use, with their consent, the services, equipment, personnel, and facilities of Federal and other agencies with or without reimbursement, and on a similar basis to cooperate with other public and private agencies and instrumentalities in the use of services, equipment, and facilities. Each department and agency of the Federal Government shall cooperate fully with the Administration in making its services, equipment, personnel, and facilities available to the Administration, and any such department or agency is authorized, notwithstanding any other provision of law, to transfer to or to receive for the Administration, without reimbursement, aeronautical and space vehicles, and supplies and equipment other than administrative supplies and equipment.

(8) to establish within the Administration such offices and procedures as may be appropriate to provide for the greatest possible coordination of its activities under this chapter with related scientific and other activities being carried on by other public and private agencies and organizations.

DEPARTMENT OF COMMERCE APPROPRIATIONS ACT OF 1963

The Department of Commerce Appropriations Act of 1963 established a requirement for the Bureau of the Budget to include in each year's budget presentation a summary of all federal programs for meteorology, including goals and expected costs. This requirement, which has been retained in Title 68 of the U.S. Code of Federal Regulations, now applies to the Office of Management and Budget.

Section 304

The Bureau of the Budget shall provide the Congress, in connection with the budget presentation for fiscal year 1964 and each succeeding year thereafter, a horizontal budget showing

a. the totality of the programs for meteorology,
b. the specific aspects of the program and funding assigned to each agency, and
c. the estimated goals and financial requirements.

OMB CIRCULAR A-62

The Bureau of the Budget issued Circular A-62 in 1963 to prescribe "policy guidelines and procedures for planning and conducting Federal meteorological services and applied research and development to improve such services...."[1] As stated in Circular A-62, these guidelines accomplished the following:

a. reaffirm the central role of the Department of Commerce with respect to basic meteorological services;
b. clarify the respective responsibilities of the Department of Commerce and the user agencies for basic and specialized meteorological services;
c. establish procedures to facilitate coordination and the resolution of outstanding issues; [and]
d. provide for evaluating user requirements within the context of a balanced and integrated Federal plan....

The Department of Commerce responded to Circular A-62 by issuing an implementation plan on January 9, 1964, which was revised on January 13, 1964.

Circular A-62 defined basic meteorological services as "all activities, that are possible within the given state of the meteorological science, required to produce or complete a description ... of the atmosphere. In general the products of this process are meteorological in nature and are not necessarily useful in such form for the operational needs of users. These services also include ... [the generation of] products needed by the general public in their normal everyday activities and for the protection of their lives and property." Specialized meteorological services are defined as "those activities ... which produce those products needed to serve the operational needs of particular user groups. These user groups include ... aviation...."

Circular A-62 required the Department of Commerce to "establish procedures designed to facilitate a systematic and continuing review of basic and specialized meteorological requirements, services, and closely related supporting research" and to "prepare and keep current a plan ... for the effective utilization of meteorological services and supporting research."

The Department of Commerce implementation plan established the OFCM (Office of the Federal Coordinator for Meteorology) to carry out these functions. The implementation plan also established the Federal Committee for Meteorological Services and Supporting Research to "provide high-level policy guidance to the Federal Coordinator, to review and validate proposed Federal meteorological plans, and to resolve differences which may arise in connection with the preparation, monitoring, and coordination of the Federal meteorological plan." That committee includes representatives at the assistant secretary level (or equivalent) from federal agencies involved in providing or using meteorological services, including the FAA, the Department of Defense, NASA, and the National Science Foundation.

Circular A-62 limited the OFCM's role by stating that "the Federal Council for Science and Technology will continue to have cognizance over basic research in the atmospheric sciences, which includes meteorology. This also includes the supporting applied meteorological research, as defined herein, in terms of its dependence upon and contribution to the atmospheric sciences." However, the Federal Council for Science and Technology is no longer active.

Circular A-62 specified that the "Department of Commerce, to the maximum extent practical and permitted by law, will provide those basic meteorological services and supporting research needed to meet the requirements of the general public or the common requirements of other agencies. The Department of Commerce will arrange for the conduct of such services by the Department, by other agencies, or by non-Federal organizations, depending upon the most effective and economical arrangements. User agencies will arrange for specialized meteorological services and supporting research when their mission requirements cannot be effectively accommodated through the basic services and supporting research.... The Department of Commerce will, to the extent consistent with effective and economical use of resources, conduct the specialized services that support the mission requirements of user agencies."

[1] Circular A-62 remained in effect when the Bureau of the Budget became the Office of Management and Budget (OMB). The original document remained unchanged, although it was then referred to as OMB Circular A-62. During June 1994, OMB rescinded Circular A-62 without replacement.

FAA/NOAA MEMORANDUM OF AGREEMENT

On January 24, 1977, the FAA and NOAA, as the parent organization of the NWS, issued the *Memorandum of Agreement Between the FAA and the NOAA for the Establishment of Working Arrangements for Providing Aviation Weather Service and Meteorological Communications*. This agreement established several significant policies regarding how the FAA and NWS would work together and comply with legislative direction for planning and conducting aviation weather services and research.

Paragraph 1.1, Collateral Duty Assignments

As a mechanism for policy and overall program coordination between the FAA and the NOAA, the Special Assistant for Aviation Affairs, NOAA, has been assigned collateral duty as Advisor on Aviation Weather Affairs to the Administrator, FAA. A statement of the function of their assignment is contained in Appendix II [see below]. As a mechanism for research and development coordination ... a representative of the FAA's Systems Research and Development Service has been assigned collateral duty as Liaison to the ... NWS. [Specified functions of this liaison include coordinating requirements for long-and short-range aviation weather research and development plans, particularly with regard to requirements associated with interface problems between NWS and FAA systems.]

Paragraph 1.2, Statements of Requirements

The FAA will continually review aviation weather requirements and the Secretary of Transportation will transmit at least annually to the Secretary of Commerce a letter of recommendations in accordance with Section 310 of the Federal Aviation Act of 1958, as amended. The NOAA will then have an opportunity to respond to the FAA requirements and take appropriate planning and budgetary actions.

Paragraph 1.3, Joint Program Review for Planning Purposes

The NOAA and the FAA will consult with each other in all long-range planning affecting aviation weather service.

Paragraph 3.2.1, FAA Procurement

The FAA shall normally procure, install, maintain, supply support, and operate all weather observation equipment which is required solely in support of aviation activities ... [except] where air traffic activity and/or government policy does not justify government budgetary support of an observational program. In this case, arrangements may be made for a Cooperator (i.e., the Air Line, Air Taxi, or others concerned) to provide the observations as required by Federal Aviation Regulations [at their own expense]. [Other parts of this agreement specify that the FAA will fund meteorological personnel and related display and dissemination equipment located at its facilities, and NOAA will fund personnel and equipment located at its facilities.]

Paragraph 3.2.3, Program Review

The FAA and NOAA shall review, jointly, existing and proposed programs and services at least annually....

Paragraph 3.4.1.2, Operating Quarters

The FAA and NOAA shall occupy adjacent quarters at the same airport whenever advantageous. Where it becomes necessary to obtain new space for operating quarters, the space requirements of both FAA and the NOAA shall be incorporated in all planning as appropriate.

Paragraph 4.2, Planning

The FAA and NOAA will coordinate all matters having to do with making and reporting weather measurements relevant to aviation needs.

Paragraph 4.3, Operating Procedures [for observations]

In general, whenever an NWS staff is stationed at an airport, that staff will perform the observation functions. Where desirable ... the FAA personnel stationed at such airports will assist ... in this observational function.... At airports staffed by the FAA but not by the NWS, the FAA, subject to mutual agreement, will take the observations.... The NOAA will maintain a quality control system and should measure at least biannually the conformance of the observational system to the established standards and take follow-up action as necessary. If at certain locations it is impractical for the NOAA to perform observational quality control functions, procedures are established to delegate this function to the FAA. The NOAA will test and certificate all FAA personnel designated to participate in the aviation weather observation programs....

Paragraph 4.3.1, Automatic Weather Detection Systems

Where either agency uses automatic weather detection systems to fulfill its observing requirements, it will coordinate the system output to include data needed by the other agency.

Paragraph 5.3, Operating Procedures [for display systems]

All requests for PWB [pilot weather briefings] for international flights will be referred to and handled by the NOAA except flights to Canada, Mexico, and certain Caribbean locations which are handled the same as domestic flights.... The NOAA will examine and certify all FAA personnel assigned to PWB duties.

Paragraph 6.3, Responsibilities [for communications]

The NOAA, after consultation with the FAA concerning aviation requirements, shall determine the ... content ... of the weather data to be collected and/or distributed.

Paragraph 6.3.1, National Circuits

The FAA, in consultation with the NOAA, has the responsibility ... [for] the national collection of observations from manned and automated sites plus the distribution of aviation weather and basic meteorological information to facilities serving aviation.... The NOAA has the responsibility ... [for] special circuits other than aviation.

Paragraph 6.9, Access by Other ... Organizations and/or Individuals....

Subscribers other than the weather observing federal agencies ... shall make application to and sign an agreement with the NOAA to receive ... access to weather data.... This is to hold the Government ... harmless for any damage which may arise from the use of the data.

Paragraph 8.4, Coordination [of research and development]

The FAA and NOAA shall collaborate in the development of requirements for aviation weather research and development. These requirements shall be contained in the annual FAA aviation weather requirements letter submitted to the Secretary of Commerce in accordance with ... paragraph 1.2. By the first of July of each year, the FAA and the NOAA shall agree on a program plan to satisfy the research and development requirements. This program plan will be carried out by the FAA or the NOAA depending on the areas of responsibility.

Paragraph 8.5, Budget Arrangements [for research and development]

The FAA will fund for R&D [research and development] in aviation weather distribution, display, and presentation ... and the NOAA will fund for R&D in aviation weather forecasting, warning, and observations.... If the FAA has an overriding requirement for meteorological R&D in the NOAA area but not included in the NOAA budget, the FAA will arrange for NOAA to conduct the R&D on a reimbursable basis or ... by other suitable arrangements.

Appendix II, Special Assistant for Aviation Affairs

In order for the Administrator of NOAA to carry out his responsibilities under Sections 310 and 803 of the Federal Aviation Act of 1958, the Special Assistant for Aviation Affairs has been established as a staff function reporting directly to the Administrator of NOAA ... [to provide] leadership regarding aviation weather service.... The Special Assistant... will be assigned collateral duty as a staff advisor on aviation weather affairs to the FAA reporting to the [FAA] Administrator for the following functions:

1. Provide advice and assistance on long-and short-range aviation weather plans and the preparation of statements of operational weather requirements....

3. Anticipate future requirements for weather service as a result of new systems ... [that are expected to come into service], i.e., air traffic control, navigational aids, and air vehicles....

5. Keep the FAA Administrator advised of the organizational functions and capabilities of the weather facilities supporting aviation requirements.

6. Assist in the coordination of aviation meteorological matters within the FAA and in the evaluation of user requirements.

7. Act in liaison between FAA and NOAA concerning aviation weather matters to assure that the operating weather service is responsive to the aeronautical needs.

REFERENCES

Department of Commerce Appropriations Act of 1963, as amended and incorporated into Title 68 of the U.S. Code of Federal Regulations.

Federal Aviation Act of 1958, as amended and incorporated into Title 49 of the U.S. Code of Federal Regulations.

Memorandum of Agreement Between the Federal Aviation Administration and the National Oceanic and Atmospheric Administration for the Establishment of Working Arrangements for Providing Aviation Weather Service and Meteorological Communications, January 24, 1977.

National Aeronautics and Space Act of 1958, as amended and incorporated into Title 42 of the U.S. Code of Federal Regulations.

NRC (National Research Council). 1993. Toward a New National Weather Service—Review of Modernization Criteria. National Weather Service Modernization Committee, National Research Council. Washington, D.C.: National Academy Press.

OMB (Office of Management and Budget) Circular A-62, November 13, 1963, and Department of Commerce Implementation Plan for Circular A-62, January 9, 1964.

Organic Act of 1890, as amended and incorporated into Title 15 of the U.S. Code of Federal Regulations.

Weather Services Modernization Act, Public Law 102–567, Title VII, October 1992.

Appendix E

ASOS Assessment

The committee examined the Automated Surface Observing System (ASOS) as part of its effort to assess the effectiveness of the federal government's existing institutional arrangements to plan and direct improvements in the aviation weather system. As mentioned in Chapter 3 (page 26), the committee identified 10 areas of ongoing concern. These concerns are as follows:

1. Availability of the data communications system. The Federal Aviation Administration (FAA) has been working since 1990 to deploy the Automated Weather Observing System (AWOS) Data Acquisition System (ADAS) that enables ASOS units to deliver their data to the national aviation weather data collection system.[1] Until they are connected to a data communications system such as ADAS, the FAA can not commission the ASOS units that have been installed. As a result, as of December 1994, hundreds of the FAA ASOS units had been installed but had not been commissioned (see Table 3-1, page 26).

2. Interpretation of ASOS readings. Automated systems are not a one-for-one replacement for human observers. Automated systems sense and report meteorological conditions differently than human weather observers. For example, a human weather observer assesses ceiling and visibility by looking at the entire visible sky at a single point in time. ASOS, on the other hand, assesses ceiling by observing a small section of the sky directly overhead and integrating over time, and the ASOS visibility sensor measures conditions between a transmitter and receiver that are less than 3 feet apart. Although these two methods "are fundamentally different, they yield similar results under most [but not all] conditions" (NWS, 1995). Users who have relied on human weather observations need to understand these differences in order to properly interpret ASOS data. Training of pilots and controllers to appreciate these differences has not kept pace with the installation of ASOS units and has resulted in user skepticism about the ASOS program and confusion about ASOS unit reliability and accuracy. (Lack of familiarity with ASOS readings can sometimes lead users to conclude incorrectly that an ASOS unit is malfunctioning.)

3. Instrument performance and system development testing. The National Weather Service (NWS) tested ASOS technology as it was developed. In addition, the initial deployment of 55 ASOS units was followed by about a year of on-site test and evaluation. In general, ASOS units have performed in accordance with design specifications. However, the NWS has had to modify many ASOS units after installation to correct deficiencies with the rain gauge, anemometer, and data-reporting algorithms that were not detected during initial system testing. It takes up to a year to implement software changes to modify the algorithms and, as a result, users sometimes perceive that the NWS is not responsive in correcting deficiencies that they report (Kisner, 1995). In fact, the NWS stopped commissioning its ASOS units for several months during late 1994 and early 1995 to correct deficiencies in installed units and to improve the ability of the NWS logistics system to supply spare parts and complete ASOS repairs in a timely fashion. In addition, early in 1995 the FAA stopped commissioning its ASOS units to conduct a 6-month performance standardization test at about 25 ASOS sites. The FAA took this action in response to concerns expressed by air traffic controllers about ASOS performance.

4. Completeness of the weather observation. As appropriate, manual weather observations contain remarks regarding approaching thunderstorms or fog, cloud type (which is especially important to pilots of small aircraft flying in mountainous regions), and other phenomena that are difficult if not impossible to detect with automated systems. These remarks provide additional detail and add to the usefulness of the observation for aviation. ASOS weather observations, however, do not include these types of comments.

Video cameras could provide remote users with a panoramic view of meteorological conditions at ASOS sites. Cameras could also enable remote users to investigate the accuracy of questionable or inconsistent ASOS

[1] ADAS will be used to communicate with both AWOS and ASOS units.

readings (such as snow when temperatures are significantly above freezing). There is currently no plan for widespread deployment of video cameras to augment ASOS or AWOS units. However, the NWS is field testing video cameras in Utah and Arizona: forecasters at two NWS offices are using video cameras to provide them with a "human presence" at two remote ASOS-equipped airports. Initial feedback from NWS staff regarding the utility of these cameras is favorable.

ASOS units also have no instruments to detect or report the presence of tornadoes, thunderstorms/lightning, virga (i.e., precipitation that evaporates before it falls to the ground), volcanic ash, or runway visual range (RVR). As a result, forecasters and other users who desire this information must find other means of obtaining it.

The NWS did not give ASOS a lightning-detection capability because it anticipated that information on lightning and thunderstorm activity would be available from other sources such as WSR-88D weather radars and the National Lightning Detection Network, which provides near-real-time locating data on cloud-to-ground lightning. The FAA intended to transmit lightning data to federal ASOS units via ADAS. ASOS units would then use this information to report the presence of nearby lightning as if they had their own lightning detection instruments. However, the ADAS acquisition contract issued by the FAA did not include the capability to transmit this data to ASOS units. In October 1994 the FAA issued an engineering change request to modify the ADAS contract to provide this capability, and the FAA anticipates that ADAS will provide ASOS with lightning data by the summer of 1996.

The NWS and FAA are modifying existing ASOS units to include a freezing rain sensor. Deployment of the freezing rain sensor started in 1995 following successful field tests during the winter of 1994–1995.

RVR is a measure of how far down the runway an approaching pilot can see runway markings (during the day when good visibility prevails) or runway lights (at night and during the day when visibility is poor). RVR is a better measure of operational conditions at airports than is visibility. ASOS does not have an RVR sensor, and this shortcoming has been a contentious issue between the FAA and users such as general aviation pilots and air carriers. Although the FAA does not believe that Federal Aviation Regulations require RVR, the FAA is working to develop a new generation of automated RVR sensors. These sensors will replace existing sensors at 258 airports in the United States (Miles et al, 1995).

5. Equal or better level of service. "FAA policy is that the performance of combined automated systems must be equal to or better than manual observation capability" (FAA, 1994). Many users, however, do not believe that ASOS meets this standard at airports that previously had human weather observers. To some extent, this perception reflects a lack of consensus between the FAA and users about what data surface observations should include. For example, air carriers did not realize that ASOS units would not provide RVR until the first ASOS units were being installed. As late as April 1995, the FAA was still working with representatives of user groups and other interested parties to establish service standards for automated surface weather observations. These standards would specify the following:

- weather elements to be reported;
- reporting accuracy for each element;
- percent availability for each element; and
- maximum service outage time for each element (FAA, 1995).

6. Augmentation of ASOS observations. Human weather observers must augment ASOS readings at locations, such as major airports, that require complete weather observations. As mentioned above, the FAA and NWS are developing automated instruments to address user needs for information on thunderstorms/lightning, freezing rain, and RVR. However, there are currently no plans to automate observations of tornadoes, virga, volcanic ash, or cloud type. It takes five meteorological technicians to provide 24-hour coverage at a single site where augmentation is needed and no other certified weather observers are available. This represents labor costs on the order of $120,000 per year. It is not yet clear how the FAA and NWS will satisfy long-term requirements for human augmentation to meet the needs of aviation weather users, including their own staffs. For example, some tower controllers believe that additional automated instruments should be developed to take over part of the augmentation responsibilities that the FAA has assigned to them.

7. Access to ASOS data. Comparisons of ASOS and human weather observations in an operational setting indicate that the weather conditions reported by ASOS units show more variability than human observations. This is primarily caused by fluctuations in meteorological conditions, which ASOS units diligently measure and report as they continuously monitor the weather. In contrast, human weather observers make hourly observations unless there is a major change that warrants making a special weather observation. In any case, the variability of ASOS observations means that users typically require access to a series of ASOS observations to develop a good understanding of the weather. Currently, up-to-the-minute ASOS readings are available only by telephoning individual ASOS units or by listening to local ground-to-air radio broadcasts. Air carriers, however, would like to have easy access to all reported ASOS data, just as many NWS offices do. This would allow them to graph ASOS data and discern trends more easily than is possible from hourly and special readings. Tower controllers, on the other hand, prefer to receive just the hourly and special observations so they do not have to recheck their ASOS displays every time a pilot asks them for a current weather observation (Ramsey and Burgas, 1995; Clark, 1995).

8. Authority of controllers to override ASOS readings. Low cloud ceilings or low visibility can curtail or shut down airport operations. During these conditions pilots waiting to takeoff or land, as well as the air traffic controllers in the airport tower, are anxious to resume operations. In the past, as soon as conditions improved, the airport's human weather observer would issue an updated visibility observation that would permit the resumption of flight operations. However, if the official source of airport weather observations is an ASOS unit, then FAA regulations require that controllers wait until ASOS reports that conditions are acceptable (unless the unit is malfunctioning and they report it out of service, in which case it can not be used as a source of official observations until it is serviced). As a safety measure, the ASOS visibility algorithm is programmed to increase reported visibility gradually when observed visibility goes up. Thus, after a thunderstorm passes through an airport and visibility rapidly increases, it may take several extra minutes before ASOS reports the increase. In this situation, FAA regulations prohibit certified weather observers such as tower controllers from overriding ASOS readings to issue a higher visibility, even if they observe that prevailing visibility is obviously higher than the visibility being reported by ASOS. This problem does not occur frequently, but when it does occur, it has a big impact on airport operations. As a result, the National Air Traffic Controllers Association has asked the FAA to grant controllers the authority to override ASOS visibility during rapidly changing weather conditions. In fact, controllers already have the authority to override ASOS visibility when they observe a lower visibility than ASOS is reporting, but the FAA is reluctant to grant controllers the authority to override ASOS visibility when they observe a higher visibility.

9. Maintenance and backup. In order to reduce the frequency and length of interruptions in flight operations, it is essential to reduce the length of tune that ASOS units at airports are out of service due to malfunction and to provide for backup weather observers while ASOS units are out of commission. This is especially important at airports that have previously relied on human weather observers. In fact, the FAA will install redundant ASOS units at major airports to ensure that ASOS malfunctions do not shut down operations, and it will install back-up sensors in ASOS units at some other airports to increase the reliability of selected instruments. In addition, the NWS has agreed to provide ASOS corrective maintenance response times of 12–36 hours, depending upon airport size and operational tempo. The FAA will develop two classes of repair actions: routine and essential. Essential repairs will be called for if commercial aircraft cannot land or depart until the observation associated with the malfunctioning instrument is available (through augmentation, redundant backup, or repair). However, as of January 1995 (when over 600 ASOS units had been installed), the FAA and NWS had not agreed upon which weather parameters should be treated as essential, and the FAA had not yet tasked the ASOS manufacturer to start installing backup sensors. Air traffic controllers at some airports designated to receive ASOS units believe that the FAA and NWS should take more aggressive action to reduce the impact of ASOS malfunctions by installing more backup systems, arranging for alternative sources of observations, or reducing repair times (Leedom, 1995).

10. Site selection. At some locations, users are concerned that ASOS site selection has been driven more by the availability of electrical power and communications than by the ability to take weather observations that are representative of the local area. Because most ASOS sensors measure meteorological conditions just in their immediate vicinity, it is important to locate them at sites that are representative of meteorological conditions in the local areas that are of greatest interest to aviation (such as runways and airport approaches).

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Appendix F

General Aviation Flight Scenarios—1994 and 2015

This appendix contains descriptive scenarios of two sample general aviation flights. The first scenario describes and critiques the current aviation weather system; the second scenario describes the system that may exist in the year 2015. Both scenarios are quoted verbatim from Appendix 6 of Federal Aviation Administration (FAA) Order 7032.15 (FAA, 1994). These scenarios are similar to those offered independently by the National Research Council in *Weather for Those Who Fly* (NRC, 1994).

The following acronyms appear in this appendix:

AFSS	Automated Flight Service Station
ARTCC	Air Route Traffic Control Center
ATC	Air Traffic Control
ATCS	Air Traffic Control Specialist
ATIS	Automatic Terminal Information Service
CD	Clearance Delivery
DUATS	Direct User Access Terminal Service
EDCT	Expected Departure Clearance Time
EFAS	En Route Flight Advisory Service
FAA	Federal Aviation Administration
NOTAM	Notice to Airmen
PIREP	Pilot Weather Report
RVR	Runway Visual Range
SIGMET	Significant Meteorological Information Report
Z	Zulu time

SCENARIO ONE: 1994

Date:	December 1, 1994
Departure Airport:	Washington National, Washington, D.C.
Arrival Airport:	Pittsburgh International, Pittsburgh, Pennsylvania
Aircraft:	N1234A, BE30/A
Proposed Departure Time:	1045 Zulu (Z)

While planning a flight from the Washington National Airport to the Pittsburgh International Airport, the pilot of N1234A telephones the Leesburg Automated Flight Service Station (AFSS) to request a standard weather briefing from the air traffic control specialist (ATCS).[1]

The ATCS identifies and reads, verbatim, three flight precaution advisories, one for instrument flight rules conditions, one for icing, and a Convective Significant Meteorological Information report (SIGMET) of thunderstorm activity that is near the aircraft's intended route of flight. Radar reports from four radar sites provide the intensity, movement, and cloud tops of the thunderstorm activity described in the Convective SIGMET. These radar reports are 45 minutes old and will not be updated for at least another 15 minutes. The data contained in these written reports does not match the depiction of thunderstorms displayed on the ATCS's weather radar presentation.

Notice to Airmen (NOTAM) information provided for the route of flight is two pages long and includes all special purpose NOTAMs for the United States. The pilot interrupts the ATCS twice to locate or confirm unfamiliar locations.

The ATCS issues the forecast freezing level and winds aloft, including temperature data, based in part on data observed from the previous day. Pilot Weather Reports (PIREPs) are not available describing tops of the cloud layer where icing is forecasted. The ATCS notes that terminal forecasts will be reissued shortly. The area forecast and flight precaution advisories have been updated; however, this data does not coincide with the current Washington National terminal forecast.

After completing the preflight briefing, the pilot of N1234A files a flight plan. The AFSS ATCS enters the flight plan into a computer that transmits the flight plan to the Host computer at the Washington Air Route Traffic Control Center (ARTCC). An air traffic control (ATC) clearance, in the form of a paper strip, will be posted at the Washington National clearance delivery position in the tower cab.

The pilot of N1234A obtains an alphanumeric weather update from one of two FAA-funded Direct User Access Terminal Service (DUATS) vendors. The pilot sifts

[1] This appendix uses "ATCS" to refer to both air traffic controllers and flight service specialists.

through numerous pages of data to determine which information is pertinent to the flight, translating, interpreting, and resolving disparities in coded text data to form a mental image of expected flight conditions.

The pilot, now seated in the aircraft, radios Washington National clearance delivery (CD) approximately 15 minutes prior to the proposed departure time to obtain an ATC clearance to Pittsburgh International Airport. The ATCS at CD relays the ATC clearance to N1234A. However, due to restricted ceiling and visibility and wet runway conditions at the destination airport, N1234A encounters a 1-hour ground delay at the Washington National Airport. CD issues an Expected Departure Clearance Time (EDCT) of 1145Z, the time N1234A can expect to depart. This is an unanticipated delay. The pilot remains in the aircraft, monitoring CD position for any possible update of the EDCT.

The CD manually passes the ATC clearance, including the EDCT, to the Washington National ground controller. At the appropriate time, the ground controller issues taxi instructions to N1234A. Due to reduced visibility and fog, the ground controller is not able to observe N1234A taxi. This requires the ground controller to maintain a mental picture of the aircraft's location. The ground controller solicits and receives position reports from N1234A. This verbiage continues until the aircraft reaches the active runway. N1234A is then instructed to contact Washington National local controller.

The local controller issues the current wind, runway visual range (RVR), departure instructions, and a take-off clearance to N1234A. Once airborne, N1234A is instructed to contact Washington National departure control. The aircraft is now under radar control.

While N1234A is climbing out from the airport, the pilot hears the departure controller broadcast a SIGMET report concerning a layer of icing south of Washington National Airport. The area described does not impact the flight of N1234A. The departure controller solicits from N1234A a report of the cloud bases and tops. This information is provided, but due to ATCS workload it is not given distribution outside of the radar facility. N1234A is instructed to contact the Washington ARTCC.

As the aircraft flies through the ARTCC airspace, the pilot asks an ARTCC ATCS for the weather conditions. The controller advises the pilot to contact Flight Watch, the En Route Flight Advisory Service (EFAS), for Convective SIGMETs and weather radar information. The Flight Watch ATCS manually plots the position of the aircraft, based on navigational aid information, to determine the aircraft's position in reference to the thunderstorms depicted on the radar display. The Flight Watch ATCS has the capability of relaying live weather data to the pilot, however, supplemental information such as thunderstorm intensity and movement is now 1 hour old and may not be applicable.

The Flight Watch ATCS issues PIREPs from other aircraft in the same vicinity indicating all aircraft are reporting no icing at N1234A's altitude. N1234A provides a PIREP to the Flight Watch ATCS on tops of clouds along the route. The ATCS, now being contacted by two other aircraft, cannot enter the PIREP into the computer until all other contacts have been completed. Additionally, the pilot has been off the ARTCC frequency while the weather question is being answered.

Some time later, another ARTCC ATCS solicits from N1234A a top of clouds report and inquires as to any additional cloud layers above. The ATCS passes this information on as a PIREP. N1234A is able to climb to an altitude that is above the clouds and precipitation. The freezing level is no factor during this portion of the flight. The ARTCC ATCS broadcasts a center weather advisory. This advisory has no impact on N1234A's flight.

N1234A has the same concerns entering the Pittsburgh terminal airspace as experienced on climb-out from Washington National. The pilot is concerned with cloud tops, thunderstorms, freezing levels, turbulence, etc. N1234A is also concerned with airfield conditions and equipment status.

N1234A listens to the Automatic Terminal Information Service (ATIS) before being instructed to contact the Pittsburgh approach controller. The ATIS does not provide all the information N1234A would like to have. Though this information is current at the time of broadcast, conditions are changing very rapidly, requiring most of this same information to be reissued, verbally, by the terminal ATCS.

N1234A hears the terminal ATCS broadcast a SIGMET. This information describes an area affected by a line of thunderstorms. The pilot, not familiar with the description of the affected area, checks a map to locate the area described. The area is 40 miles northwest of Pittsburgh and does not affect the flight.

There are thunderstorms around much of the Pittsburgh International Airport. These thunderstorm echoes, depicted on the ATCS's display, are derived from a ground-based ASR-9 [air traffic control radar] sensor. The pilot's airborne weather radar depicts the contours of the thunderstorms differently in area and intensity, and does not show thunderstorm activity behind the first significant return. The terminal ATCS plans to vector the aircraft to the north side of the thunderstorms. The pilot's display indicates clear passage to the south side. The pilot and ATCS are receiving weather information from different sources. Each is trying to describe the presentation they see to the other.

The terminal ATCS solicits a PIREP from N1234A. Due to a sustained increase in workload, it is not passed on to the appropriate AFSS for 20 minutes.

N1234A is issued the runway braking action and RVR by the terminal ATCS, then receives an approach clearance with instructions to contact the Pittsburgh tower local controller. The local controller reissues to N1234A wind information, runway braking action, and the RVR. N1234A receives a clearance to land.

In retrospect, N1234A received weather information that was often incomplete, inconsistent, and outdated. The AFSS ATCS spent valuable time interpreting alphanumeric data. Radar information was often too old to be useful by itself. The Flight Watch ATCS was unable to relay accurate information on thunderstorm cells and the exact location of potential icing and turbulence. The PIREPs were not disseminated at their time of receipt due to equipment limitations.

The terminal and ARTCC ATCSs were overly involved with the issuance of routine weather information. The exchange of weather information between pilot and ATCS was time-consuming, work-intensive, and caused frequency congestion that affected airspace capacity and ATC efficiency.

SCENARIO TWO: 2015

Date:	December 1, 2015
Departure Airport:	Washington National, Washington, D.C.
Arrival Airport:	Pittsburgh International, Pittsburgh, Pennsylvania
Aircraft:	N1234A, BE30/S
Proposed Departure Time:	1045 Z

While planning a flight from the Washington National Airport to the Pittsburgh International Airport, the pilot of N1234A obtains a detailed weather briefing from the ATCS at the preflight position at the Leesburg AFSS.

The AFSS has composite display available for the pilot's entire route of flight which allows the specialist to describe individually flight tailored information that indicates precisely where a line of thunderstorm activity will be located. The display is capable of overlaying individual areas with annotations of tops, intensity, and movement. The need for Convective SIGMET and radar reports has been eliminated by current and forecast annotated radar information. NOTAM information for the route of flight is displayed only for navigational aids and landing areas pertinent to the route of flight.

Turbulence, icing, and winds aloft information is denoted into a weather severity index by route and altitude and displayed graphically, eliminating the need for vague and extensive weather advisories. Radar reflectivity information is confirmed by satellite data which can be looped and overlaid over other graphics. PIREPs have been automatically received via data link from aircraft in flight and are included in the graphic display. The ATCS is no longer required to read, verbatim, routine alphanumeric data.

The ATCS queries the computer for the most favorable flight altitude for the BE30. The most favorable altitude and associated wind data are displayed graphically for the route. The location of wind direction and speed changes is clearly depicted.

The pilot of N1234A could have obtained the same graphics and weather presentation by accessing the DUATS located at a fixed base operator or through a home personal computer. The data base and graphics utilized by DUATS are the same data base utilized by the Leesburg AFSS.

The pilot of N1234A files a flight plan via a computer terminal. It is transmitted to the Host computer at the Washington ARTCC. An ATC clearance is electronically posted at the Washington National clearance delivery position in the tower cab. Simultaneously, the pilot of N1234A receives an ATC clearance to the Pittsburgh International Airport through the predeparture clearance delivery function at the Washington National airport traffic control tower. N1234A receives an EDCT of 1145Z, a 1-hour ground delay at the Washington National Airport due to restricted ceiling and visibility and wet runway conditions at the destination airport, Pittsburgh International. The pilot is able to plan for this delay in departure.

Having no need to reconfirm any clearance information, N1234A calls Washington National ground control for taxi instructions. Ground control has prior notification that N1234A will call due to a scroll of an EDCT list. The controller is aware that the pilot has been delayed on the ground and that the ATC system is now able to allocate airspace for this aircraft. Automation tools help direct the aircraft to the appropriate runway as reduced visibility and fog restrict the ATCS's ability to see the aircraft taxi. Ground control monitors N1234A's progress on the airport surface detection equipment. Some limited verbal communications are still required.

The Washington National local controller issues departure instructions and a takeoff clearance to N1234A. The aircraft is data link equipped; this is annotated electronically on the ATCS's display. The requirement to issue wind and RVR information is no longer necessary, as this information is transmitted via data link. Data link technology enables the local controller to devote more time and attention to the separation and sequencing of aircraft. Once airborne, N1234A is instructed to contact Washington National departure control. The aircraft is now under radar control.

While N1234A is climbing out from the airport, pertinent weather affecting the route of flight is transmitted via data link to the aircraft, with no ATC involvement. N1234A files a PIREP on the bases and tops of cloud layers via data link. This PIREP is automatically disseminated to users in need of such information, including ATC.

Throughout the flight, N1234A receives and solicits weather information through a common data base via an onboard computer. Wishing to confirm the exact location of predicted thunderstorm activity, N1234A contacts Flight Watch. The Flight Watch ATCS enters the aircraft's identification into the computer. The aircraft's position is automatically depicted on the display along with the projected route of flight. The Flight Watch ATCS is able to provide N1234A with individually flight tailored information that depicts the exact location of hazardous weather and projections of movement in time and distance along the route of flight.

The Washington ARTCC receives information indicating a severe thunderstorm in the flight path of N1234A. The ARTCC ATCSs are able to depict this, in three dimensions, on their common console. Planning commences to direct N1234A, and all other affected aircraft, from this thunderstorm. Before N1234A reaches this thunderstorm, a reroute is received from ATC via data link ensuring clearance from it. N1234A, able to depict the same presentation of the thunderstorm on its onboard computer, has anticipated the reroute. PIREP and NOTAM information are similarly transmitted via data link to the aircraft.

N1234A listens to the ATIS before being instructed to contact the Pittsburgh approach controller. The ATIS broadcast, along with the accurate weather information received throughout the flight, prepares the pilot for arrival to Pittsburgh.

Both the pilot of N1234A and the approach controller share the same weather information, in graphic presentation. N1234A is vectored around hazardous thunderstorms north of the airport. The pilot anticipated the situation and was able to plan for this reroute.

N1234A, during the arrival phase of flight, receives continuous wind, braking action, and RVR information from the heads-up display that interfaces with the data base. The terminal ATCS issues an approach clearance to N1234A with instructions to contact the Pittsburgh tower local control. The local controller, at this point, issues a clearance to land N1234A. The local controller also receives continuous wind, braking action, and RVR information, for ATC planning purposes, from the beads-up display in the tower cab.

In retrospect, N1234A and the ATC system received weather information which was complete, consistent, pertinent, and accurate. The pilot was able to obtain an individually tailored preflight briefing from the AFSS ATCS in a minimum amount of time. The ATCS was able to focus on providing a service versus spending a large amount of time analyzing and interpreting data. The terminal and en route ATCSs utilized weather information for strategic and tactical ATC planning. The terminal and ARTCC ATCSs, no longer a conduit of routine information, were able to provide much better ATC services to N1234A.

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Appendix G

Federal Funding

Both the source and amount of funding for aviation weather services have a profound impact on aviation weather services and related research. The amount of funding defines the overall level of effort that federal agencies devote to aviation weather services. In addition, the distribution of funding defines which agencies have practical control over the specific aviation weather programs. As shown in tables G-1 and G-2, the Federal Aviation Administration (FAA) and Department of Defense (DoD) are the primary source of federal funding for aviation weather services and related research. Although the National Weather Service (NWS) provides many important services related to aviation, the FAA has specific agreements with the National Oceanic and Atmospheric Administration (NOAA) to reimburse it for most of the aviation-specific services and research that it provides. Similarly, NOAA pays the National Aeronautics and Space Administration (NASA) to procure and launch meteorological satellites. During fiscal year 1995, such interagency transfers amounted to $79 million (from the FAA to NOAA) and $256 million (from NOAA to NASA).

TABLE G-1 Federal Budget Summary For Meteorological Services, Fiscal Year (FY) 1992–1996 (millions of dollars)a (Source: OFCM, 1992–1995)

		FY 1992	FY 1993	FY 1994	FY 1995	FY 1996
FAA	All areas	$396	$349	$360	$426	$333
	Aviation only	396	349	360	426	333
NOAA/NWS	All areas	826	870	1,090	1,084	1,218
	Aviation only	35	36	50	36	36
DoD	All areas	665	523	506	504	464
	Aviation only	192	362	329	326	296
NASA	All areas	7	7	8	4	4
	Aviation only[b]	N/A	N/A	N/A	N/A	N/A
Other Federal Agencies	All areas	14	18	20	20	19
	Aviation only	0	0	0	0	0
Federal Government Total	All areas	$1,908	$1,767	$1,984	$2,038	$2,038
	Aviation only	**623**	**747**	**739**	**787**	**664**

[a] Funding for fiscal years 1992–1995 reflects congressionally appropriated funds. Funding for fiscal year 1996 reflects the amount requested in the President's fiscal year 1996 budget submission to Congress. Figures may not total due to rounding.

[b] These figures are not available because NASA does not break down fuming for meteorological services into application areas such as aviation.

TABLE G-2 Federal Budget Summary For Meteorological Research, FY 1992–1996 (millions of dollars)a (Source: OFCM, 1992–1995)

		FY 1992	FY 1993	FY 1994	FY 1995	FY 1996
FAA	All areas	$28	$34	$26	$19	$23
	Aviation only	28	34	26	19	23
NOAA/NWS	All areas	54	47	79	88	89
	Aviation only	2	2	2	2	2
DoD	All areas	89	69	99	104	100
	Aviation only	0	11	25	53	35
NASA	All areas	153	155	166	164	145
	Aviation only[b]	N/A	N/A	N/A	N/A	N/A
Other Federal Agencies	All areas	21	24	24	24	24
	Aviation only	0	0	0	0	0
Federal Government Total	All areas	$346	$329	$393	$400	$381
	Aviation only	**30**	**46**	**63**	**73**	**59**

[a] Funding for fiscal years 1992–1995 reflects congressionally appropriated funds. Funding for fiscal year 1996 reflects the amount requested in the President's fiscal year 1996 budget submission to Congress. Figures may not total due to rounding.
[b] These figures are not available because NASA does not break down funding for meteorological research into application areas such as aviation.

TABLE G-3 FAA Budget Summary, FY 1993–1996 (millions of dollars) (Source: FAA)

	Fy 1993	FY 1994	FY 1995	FY 1996
Aviation Trust Fund Receipts	**$6,100**	**$6,279**	**$6,509**	**$6,700**[*]
Total Budget Authority	**$8,910**	**$8,644**	**$8,644**	**8,380**[*]
FAA Grants-in-aid	1,800	1,690	1,450	1,500[*]
Operations	4,530	4,580	4,591	4,704[*]
Facilities and Equipment	2,350	2,120	2,087	1,908[*]
Research, Engineering, and Development	230	254	259	268[*]

[*] Estimates

Unlike most federal agencies, the budget of the FAA is supported primarily by taxes levied directly on users of agency services (see Table G-3). In particular, the Aviation Trust Fund receives taxes collected on airline tickets, aviation fuel, air cargo, and international passenger departures. (During 1993, 88 percent of trust-fund receipts derived from the airline ticket tax.) The trust fund is then used to fund a portion of the FAA's activities as well as grants-in-aid to help pay for improvements in domestic airports and airways. However, trust-fund expenditures have not kept pace with receipts. Although the trust funds received $6.1 billion during fiscal year 1993, the government transferred $1.9 billion to the general treasury, leaving the trust fund with a net income of only $4.2 billion. In addition, in order to reduce the size of the federal budget deficit, the federal government has not authorized the expenditure of all funds collected by the trust fund. As of March 1995, this had produced an unexpended surplus of about $12 billion that could have been used to hasten improvements to air traffic management and aviation weather systems.

As shown in Table G-3, the FAA has been challenged in recent years by reductions in funding, but smaller budgets have not been accompanied by a lessening of the FAA's roles and missions. In order to accommodate these reductions, the FAA has responded by trying to eliminate funding for some functions (e.g., the Direct User Access Terminal Service, DUATS) and revising the way it provides others (e.g., the consolidation and modernization of its Flight Service Stations, FSSs). This has sometimes resulted in negative feedback from members of the public who use the services that the FAA provides, and the FAA has had to continue funding some services that it planned to discontinue (e.g., DUATS) and to modify proposed changes to other systems (e.g., FSSs).

Table G-4 illustrates how FAA expenses are allocated among its major facilities and user groups.

TABLE G-4 The FAA's Allocated Costs of Providing Air Traffic Control Services to Various User Groups, Fiscal Year 1993 (millions of dollars) (Source: DOT, 1994)

	Air Carrier	Air Taxi & Commuter	General Aviation	Military	Total
ARTCCs	$1,661	$447	$406	$606	$3,120 (50 %)
Facilities at Major Airports[a]	1,191	678	350	330	$2,549 (41%)
Other Towers	16	21	150	25	$211 (3%)
FSSs	5	15	357	9	$385 (6%)
Total	**$2,872 (46%)**	**$1,160 (19%)**	**$1,262 (20%)**	**$969 (15%)**	**$6,264 (100%**

[a] This represents the cost of control towers and Terminal Radar Approach Control (TRACON) facilities at airports that have TRACONs. "Other towers" are towers located at airports without TRACONs.

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Appendix H

Research Documents and Organizations

The current aviation weather research and development program is described in the following federal planning documents:

- The *National Aviation Weather Program Plan*, which the Office of the Federal Coordinator for Meteorology (OFCM) issued during 1992, discusses user needs, existing aviation weather systems and services, and unmet needs; provides an assessment of planned systems; and makes recommendations for research and development. This plan notes that successful implementation of future systems depends upon effective communication and coordination among all agencies involved and rapid transfer of research and development results to operational services (OFCM, 1992).
- The 1994 *U.S. Weather Research Program (USWRP) Implementation Plan* is an interagency document that describes federal weather research goals and priorities and specific activities needed to achieve these goals and priorities. This plan recommends that representatives of the USWRP, Federal Aviation Administration (FAA), and Department of Defense (DoD) continue and expand collaboration on aspects of their research and development programs that have commonality. Specific areas identified include advanced forecast models and in flight weather hazards such as icing (USWRP, 1994).
- The 1994 *FAA Strategic Plan* describes an evolutionary strategy to develop the aviation weather system of the future. This strategy focuses on developing prototypes of future systems quickly to ensure that interfaces with other systems and operational concepts are thoroughly validated. The plan calls for testing prototypes in an operational environment to allow user evaluation teams to help refine system performance (FAA, 1994b).
- The *1994 FAA Plan for Research, Engineering and Development (RE&D)* discusses three projects that are funded by the RE&D budget: (1) aviation weather analysis and forecasting, (2) airborne meteorological sensors, and (3) integrated airborne windshear research. The *RE&D Plan* also refers to three other projects that are funded under the FAA's Capital Improvement Plan: (1) the Integrated Terminal Weather System, (2) the Aviation Gridded Forecast System, and (3) the Advanced Weather Products Generator, which the FAA subsequently decided to eliminate from its budget proposal for fiscal year 1996. The RE&D Plan anticipates rapid prototyping and operational evaluation of new systems by federal laboratories to facilitate the development of operationally acceptable products and services (FAA, 1994a).

The FAA works with the National Science Foundation to sponsor aviation weather research by the National Center for Atmospheric Research (NCAR) and three university groups. The FAA also provides funding directly to National Oceanic and Atmospheric Administration (NOAA) Forecast Systems Laboratory (FSL), the Massachusetts Institute of Technology (MIT) Lincoln Laboratory, and the MITRE Corporation. In addition, the National Aeronautics and Space Administration (NASA) and the DoD sponsor research and development activities related to aviation weather. Aviation weather research associated with these organizations is discussed below.

Forecast Systems Laboratory. FSL is developing the Aviation Gridded Forecast System. This system was intended to provide inputs to the Advanced Weather Products Generator, but (to this committee's astonishment) the FAA has terminated its support for the Advanced Weather Products Generator and plans to encourage private weather services to take over the task of developing improved weather products.

FSL also develops weather displays, products, and productivity tools and refines them in air traffic and weather forecasting facilities operated by the FAA and National Weather Service (NWS). The laboratory then transfers validated new technology to the NWS's National Centers for Environmental Prediction (formerly the

National Meteorological Center) and the FAA. For example, the FSL is developing the Local Analysis and Prediction System, which will enable Weather Forecast Offices to create local forecast grids. FSL is currently test-operating a developmental version of this system for the Colorado geographic area.

National Center for Atmospheric Research. The overall goal of NCAR's Research Applications Program is to develop meteorological products for the aviation community that will improve safety, increase efficiency, provide additional capacity, and generally reduce the cost of aviation operations. NCAR focuses on scientific problems and the resolution of scientific issues related to the development of new products. NCAR conducts rapid prototyping and works with aviation users, such as air traffic controllers and air carriers, to obtain feedback on new concepts. In general, NCAR transfers improvements in en route weather information to the NWS through FSL, and it transfers improved terminal area improvements to the FAA through MIT Lincoln Laboratory.

NCAR is currently focusing on issues related to icing, turbulence, and convective weather detection and forecasting. NCAR has also concentrated on the Advanced Weather Products Generator as a means of providing improved production and display of aviation weather information and decision aids. NCAR also contributes to the development of advanced weather radars and airborne sensors. During fiscal years 1994–1995, funds for the NCAR and university research programs have decreased from about $15 million per year to approximately $5 million, and further cuts are scheduled for fiscal years 1996–1997.

Universities. Three university groups are performing basic and applied research aimed at scientific issues of particular interest to aviation, including detection and modeling of convective phenomena; improving terminal forecasts of aviation critical variables, such as cloud height and visibility; and mesoscale modeling. Results from this research will be incorporated in the other activities as it becomes available.

MIT Lincoln Laboratory. Lincoln Laboratory is developing the Integrated Terminal Weather System to integrate weather information from a wide variety of sources, including FAA airport radars, and thus produce a comprehensive depiction of conditions affecting flight near major airports.

MITRE. The FAA funds the MITRE Corporation's Center for Advanced Aviation System Development (CAASD) to validate system requirements and support the development of incremental improvements to the aviation weather system. For example, CAASD has used its simulation capabilities to determine that the high quality of data produced by the new WSR-88D weather radars allows them to outperform existing airport radar systems by a wide margin. CAASD determined that the relatively slow update rate of the WSR-88D (once every 5 minutes) is not an operational issue even for high-speed (40-knot) weather systems. CAASD then verified the results of this simulation by monitoring the movements of aircraft during adverse weather (MITRE, 1994).

NASA. As shown in Table G-2 (page 91), during fiscal year 1995 the NASA budget for meteorological research and systems development represented over 40 percent of the federal government's entire (i.e., not just aviation-related) meteorological research and development budget of $400 million.[1] NASA's areas of interest in aviation weather include windshear, icing, lightning, and en route dissemination of weather information. For example, NASA led the development of airborne windshear detection and avoidance technology that has been incorporated in a commercial Doppler radar system that is being deployed by several U.S. and international air carriers. Ongoing NASA programs, some of which are partly funded by the FAA, are (1) developing ground and airborne technology to reduce the impact of reduced visibility and cloud ceilings on airport operations, (2) investigating alternatives for designing aircraft with improved icing resistance, and (3) evaluating the effectiveness of using a satellite-based ozone mapping spectrometer for nowcasting volcanic hazards and upper-air winds. In general, NASA focuses on issues related to aircraft design, such as the impact of icing on aircraft performance, rather than on forecasting, and its work is conspicuously absent from federal aviation weather planning documents.

Department of Defense. The Air Force and Navy conduct most of the DoD's meteorological research and development. The Air Force Materiel Command works with the Air Force Air Weather Service and appropriate elements of the U.S. Army to develop meteorological systems needed to support Air Force and Army operations. The Oceanographer of the Navy is the Navy's central point of contact for identifying meteorological requirements and monitoring meteorological research and development projects as they transition to operational status.

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[1] Unlike many other federal agencies, NASA does not report how much of its meteorological research is focused specifically on aviation applications. NASA's meteorological research supports projects, such as the space-based Earth Observing System, that do not directly impact aviation.

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OFCM (Office of the Federal Coordinator for Meteorology). 1992. National Aviation Weather Program Plan. Washington, D.C.: OFCM.
USWRP (U.S. Weather Research Program). 1994. U.S. Weather Research Program Implementation Plan. Washington, D.C.: Department of Commerce.

Appendix I

Detailed Assessment of User Needs in Alaska

As discussed in Chapter 5, some geographic regions of the United States have environmental conditions and user needs that vary significantly from the national norm. However, the federal system for providing aviation weather services is based on conditions and needs that prevail in much of the nation. Alaska, more than any other region of the United States, seems to have an aviation environment that differs from national norms. Therefore, the committee was formed with two members from Alaska, an aviator and a climatologist. In addition, seven committee members met for 3 days in Alaska to consider how the special needs of this region illustrate the difference between national and regional needs for aviation weather services. This appendix contains additional information that supports the findings and recommendations on regional requirements that appear in Chapter 5.

During its visit to Alaska, the committee used Anchorage as a central gathering point. Committee members met with officials from local offices of the Federal Aviation Administration (FAA), National Weather Service (NWS), and National Transportation Safety Board (NTSB). The committee also held a group discussion about Alaskan aviation weather with personnel from several Alaskan air carriers, professional and industry associations connected with Alaskan aviation, the Alaskan Department of Transportation, and the Alaska Air National Guard. (Participants in this discussion axe included in Appendix C.)

The most demanding aspects of Alaskan aviation manifest themselves in the small communities outside Anchorage. Accordingly, committee members and staff dispersed individually to communities throughout Alaska: to Barrow, Bethel, Deadhorse, Dillingham, Juneau, Kodiak, and Valdez. At Juneau and Dillingham, they also participated in local flights to some of the outlying villages. They spoke informally with the pilots, dispatchers, pilot briefers, passengers, and others who deal on a daily basis with the impact of Alaskan weather on aviation operations. The aviators in these locations provide service to village airfields that often consist of little more than a gravel runway and a wind sock. Even more rigorous are wilderness hunting/ fishing, medical evacuation, and search and rescue missions to destinations that have no support services whatsoever. The challenges faced by the pilots who fly these types of missions are in many ways similar throughout the country.

FACTORS THAT DEFINE REGIONAL VARIABILITY

As noted above, this appendix uses Alaska as an extreme example of how regional environmental conditions and user needs may vary from national norms. The following factors are of particular significance in describing regional characteristics:

- geography and weather patterns;
- transportation systems;
- other elements of the regional infrastructure;
- cultural differences;
- economic factors;
- regulatory factors; and
- FAA and NWS organization and operations.

A discussion of the manner in which each of these factors is relevant to Alaska appears below.

Geography and Weather Patterns

In absolute terms, Alaska has an enviable number of aviation weather assets such as weather observation sites, weather radar installations, and Flight Service Stations (FSSs).[1] However, the adequacy of these assets is tremendously diminished by the sheer size of the state. As shown in Figure I-1, the state capital is over 550 miles from Anchorage, the major city, and 850–1150 miles from the

[1] Unless otherwise indicated, this appendix uses the abbreviation "FSS" to refer to all three types of flight service stations as a whole. The three types are (1) traditional Flight Service Stations (FSSs), most of which are being closed throughout the United States; (2) Automated Flight Service Stations (AFSSs), which are replacing traditional FSSs; and (3) part-time and seasonal Flight Service Stations, which are taking the place of about 14 traditional FSSs in Alaska.

state's east and north coasts. The land area of Alaska exceeds the combined area of Texas, California, and Montana. As a result, the geographic density of aviation weather facilities is much less than the density of equivalent facilities in the contiguous 48 states. For example, Alaska's 3 NWS forecast offices are together responsible for a total area of over 1,260,000 square miles. The NWS's Alaska Regional Office calculated that the average area of responsibility of these offices is 10 times larger than the national average.

In addition to its large size, Alaska has a well-earned reputation for climatic extremes and weather fluctuations that impact all modes of transportation. Even during the summer, aviation is restricted by freezing levels that are often less than 7,000 feet. Bemuse most of the small aircraft operating in Alaska are not certified to operate in icing conditions, the freezing level serves as an upper limit on aircraft altitude whenever the atmosphere contains enough moisture to create an icing hazard. This limit on altitude is particularly important in mountainous regions where the terrain is higher than the freezing level. This situation restricts many pilots to mountain passes that can become very dangerous in the presence of unexpected adverse weather. Improved icing forecasts would improve the ability of pilots to avoid mountainous terrain by flying at higher altitudes (in cases where their aircraft have the ability to operate at altitudes that exceed the height of mountains along their flight path). Improved forecasting would also enable more flights under instrument flight rules (IFR) by aircraft that have limited anti-icing capability

Many of Alaska's small communities depend upon aviation for basic transportation. For reasons discussed in the following section on transportation systems, there are no roads between many near-by communities, and it is, therefore, impractical for clusters of communities to share a regional airport. As a result, Alaska has a large number of aviation destinations. Like the size of Alaska, the sheer number of airfields complicates the process of continually producing accurate and up-to-date terminal observations and forecasts. In fact, the NWS generates terminal forecasts for only 15 percent (36 of 239) of the airports in

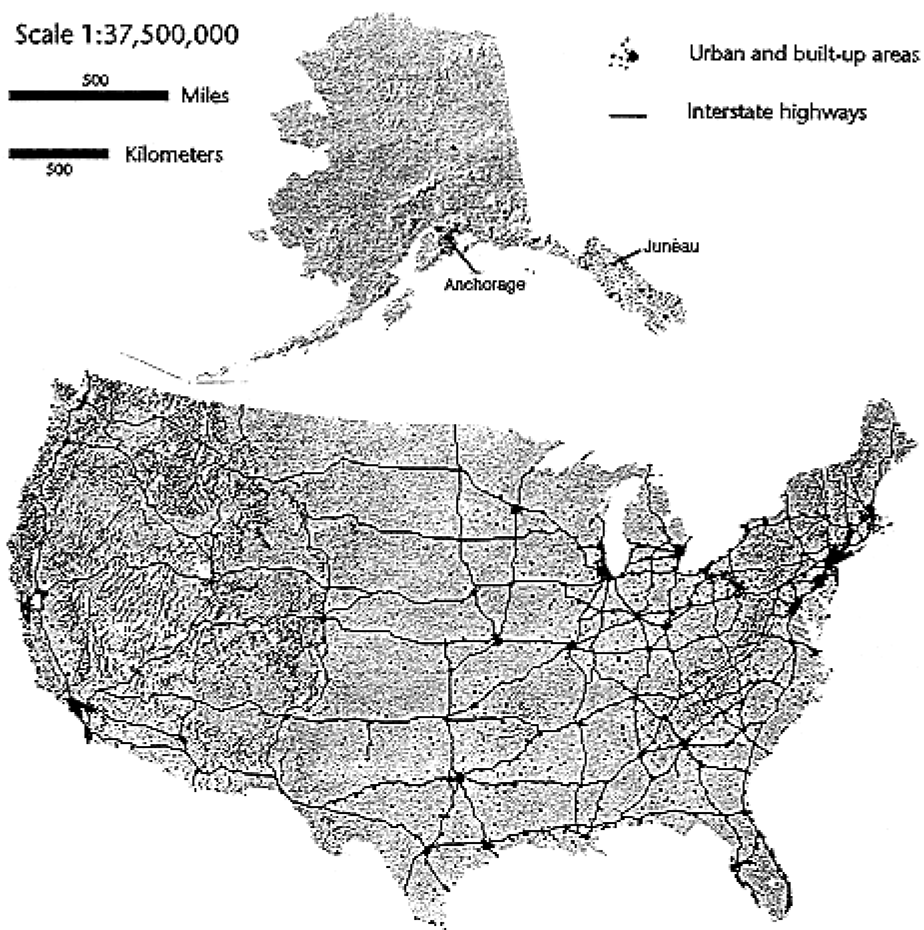

Figure I-1.
Geographic extent of Alaska and the contiguous 48 states.

Alaska that receive scheduled passenger service by major, regional, or commuter air carriers. In the other 49 states, however, the NWS produces terminal forecasts for 88 percent (462 of 524) of the airports that receive scheduled passenger service (NWS, 1994; RAA, 1995).

Satellite imagery is an indispensable tool for NWS forecasters to monitor weather conditions in remote regions where no ground-based observations are available. The availability of high-quality imagery, however, is more limited for Alaska than for other parts of the United States. Geostationary weather satellites, which orbit above the equator, do not get a good view of highlatitude areas such as Alaska. Although polar-orbiting weather satellites do provide excellent imagery of highlatitude regions, they pass overhead only once every 6 hours or so. This frequency is too low for the fast-changing weather conditions that many parts of Alaska often experience.

Even over short distances, Alaska features a variety of terrain and terrain-induced microclimates. As a result, existing weather information systems are often unable to provide accurate information on current or forecast weather conditions along low-altitude flight paths. For example, three scheduled air carriers and several air taxis provide service between the town of Dillingham and Togiak, a village located 35 miles to the north. Most of the flights are by aircraft flying under visual flight rules (VFR). Three lines of hills about 2,000 feet high separate Togiak from Dillingham. There are no communities or weather observing stations to monitor weather conditions in the two valleys between the hills. It is not unusual for low clouds to prevent pilots of VFR aircraft from flying over the hills. When that happens, they fly through lowlevel passes in each line of hills. In order to determine if weather conditions in these passes are safe, an experienced pilot is chosen to make the first flight of the day; if unacceptable weather is encountered, the pilot reverses course. Otherwise, the pilot proceeds on and reports weather conditions via radio. This type of situation is common along many of Alaska's flight paths.

The military often uses the same approach on search and rescue missions in Alaska because there generally are few sources of good information regarding flight conditions, especially during the harsh weather conditions that accompany many such missions. A C-130 is often dispatched as the lead aircraft to observe weather conditions and report back to the rescue helicopter, which is more susceptible to adverse weather.

Mountainous terrain can generate locally hazardous conditions, such as turbulence, windshear, and downdrafts, that the existing aviation weather system may not detect or predict. Pilots can prevent these conditions from causing accidents by flying at higher altitudes. However, this is not always possible with some general aviation aircraft became of icing conditions or aircraft performante limitations at high altitudes. Accidents also occur whim pilots see signs of hazardous mountain weather but fail to recognize the implied hazard or lack the piloting skills to avoid it. Options for reducing general aviation accidents in mountainous terrain include deployment of additional weather sensors, improved forecast techniques, and better training of general aviation pilots who fly in mountainous terrain (Kelley et al, 1995; Lamb and Baker, 1995).

Active volcanoes, which are present in both Alaska and Hawaii, place special requirements on aviation forecasters. Volcanic ash plumes can seriously damage aircraft that fly through them. As a result, volcanic eruptions can seriously disrupt air traffic, especially in Alaska when ash plumes intersect trans-Pacific flight routes. Fuel reserves may greatly restrict the options available to aircraft that are already in the air when eruptions occur. Became many of Alaska's 42 active volcanoes are located in remote, uninhabited areas, meteorologists must rely on satellite imagery to detect, track, and project the movement of ash plumes. In order to be effective, this means that meteorologists must be able to distinguish ash plumes from normal clouds of water vapor (Kelley et al, 1995).

Transportation Systems

The Alaskan intercity road system consists of a limited network of state roads in the eastern half of the state. Paved roads extend from Canada to Anchorage, Fairbanks, and the seaports of Seward and Valdez. There is also a gravel road to Prodhoe Bay on the North Slope. However, Alaska has no federal or interstate highways. In fact, there are no paved intercity roads of any kind in the north or west. The state capital of Juneau is also inaccessible by road from either Canada or the rest of Alaska. Mountains, permafrost, harsh weather, and environmental regulations (which were not in effect when most of the U.S. interstate highway system was built) would make it extremely difficult and expensive to expand the current road system to serve a significantly larger fraction of Alaska's communities.

Although many Alaskan towns and villages do have local roads, cars and trucks are solely for use in town. Coastal communities can import motor vehicles by barge during the summer. Otherwise, they are brought in as air freight. The manager of the Dillingham FSS reported paying about 50 cents per pound to have his new car flown in.

As already mentioned, many communities are accessible by ship during the summer. In addition, travel via snowmobile is feasible during the winter. During the spring and fall, however, 70–75 percent of Alaska's communities are completely isolated except by air. Ice blocks ship traffic, and there is not enough snow for snowmobiles. Thus, as a matter of necessity, Alaska has developed a transportation network of small aircraft to meet the needs of its outlying towns and villages. This transportation network features an extremely atypical reliance on low-level VFR aircraft. Although adverse weather suppresses VFR flights for much of the year, activity blossoms during good (or marginal) weather to make up for lost time. During the summer months, about 95 percent of all flights in Alaska are VFR. Even if they have IFR capabilities, many small aircraft operate under VFR because most airfields do not have the IFR approaches and official weather observations that are needed for IFR operations.

In lieu of a comprehensive road system, the state of Alaska has funded the construction and maintenance of 450 airfields throughout the state. The state assumed this responsibility because local communities, which may have only a few hundred inhabitants, do not have the financial resources to construct or maintain airfields. Despite the small size of many local populations, these airfields are justified by the lack of any other transportation alternatives. The situation is analogous to small towns in the rest of the country that rely on state governments to build and maintain intercity roads.

Most of Alaska's airfields have gravel runways and very limited facilities. Only 3 of the 450 airfields are financially self-sufficient; operation of the others is a significant financial undertaking. Just keeping the airfields plowed during the winter is a big challenge—snow removal consumes 97 percent of the funds allocated for maintenance and operation of rural Alaskan airports. At present, the state of Alaska views airport maintenance and operations—not aviation weather services—as its primary focus and its most important contribution to Alaskan aviation. Alaska views aviation weather services as a federal responsibility, and it does not follow the precedent set by nine states (including Virginia, Minnesota, Wisconsin, Iowa, and Pennsylvania) that have decided to operate their own weather observation and dissemination systems.

Although the state of Alaska made six separate attempts to establish state-operated aviation weather observation and/or dissemination systems during the early 1980s, the task of installing, operating, and maintaining aviation weather facilities and equipment proved to be more challenging and costly than anticipated. Each attempt resulted in almost total failure. Ultimately, the state donated most of the navigation beacons it acquired to the FAA and local governments. In addition, most of the communications equipment purchased during these attempts was put into storage due to lack of funds. While in storage, the majority of this equipment became obsolete and is no longer suitable for installation under current rules of the Federal Communications Commission. Although the Alaska Department of Transportation and Public Facilities recognized that weather services needed to be improved in order to reduce the aviation accident rate in Alaska, these efforts had very little lasting impact on the state's aviation safety or efficiency (DOTPF, 1995).

Like the rest of the United States, Alaskan aviation depends heavily on the hub-and-spoke system. Regional air carriers provide scheduled service from the major population centers (Anchorage, Juneau, and Fairbanks) to the larger towns. Small air carriers and air taxis operate from these towns to provide service to surrounding villages. Typical seating capacity in most of the aircraft serving these villages is about six, including the pilot, and many aircraft have removable seats to facilitate a variable mix of cargo and passengers. Typical cargo varies from groceries and household goods to tools and other industrial supplies. Typical passengers include villagers going to town for the day and high school athletes flying to a neighboring town for a game.

Alaska once had over 30 traditional FSSs. The FAA is replacing these facilities with 3 centralized AFSSs and 14 part-time or seasonal FSSs. This means that pilots will be less likely to find an FSS on their flight path, especially during the winter months, when seasonal FSSs will be closed. The consolidation of the FSSs also means that fewer FSS employees live in the areas they serve; FSS employees will rotate between the AFSSs and the part-time/seasonal FSSs. This is likely to hinder the development of mutual understanding between aviators and flight service specialists regarding the difficulties and challenges that each profession faces. Rotarion of FSS employees will also make it difficult for flight service specialists to gain an in-depth understanding of the local area around each FSS.

Understanding local conditions is particularly important in areas where complex topography leads to the formation of localized updrafts and downdrafts and, hence, to the formation of complex patterns of visibility, winds, turbulence, and icing. Local flight service specialists, who are familiar with local weather patterns and topography, are more likely to be able to provide accurate, detailed guidance for these areas than flight service specialists who are stationed at an AFSS hundreds of miles away or who rotate into a seasonal FSS for only a few months.

Based on the committee's investigation of Alaskan aviation weather services, it seems that the level of services has degraded over the last 20–30 years. Part of the degradation in aviation weather services has been caused by factors beyond the control of the FAA and NWS. For example, the Department of Defense and the U.S. Coast Guard have reduced the number of sites that produce weather observations from about 80 to less than 30. There are also far fewer oil and mineral exploration sites producing weather reports than there were at the height of Alaska's oil boom. Nonetheless, the Alaskan aviators seem to have a valid concern that changes in the FSS system are contributing to this degradation. For example, local aviators in Bethel were disappointed that their airfield, which serves as a hub for 30 outlying villages, would lose its FSS while other airports, with less air traffic, would keep theirs (as a part-time or seasonal FSS). Although the control tower at Bethel will provide an ongoing FAA presence, local users did not believe that this justified shutting down the FSS, and they had little confidence that they would receive an equal or better level of service without the FSS.

Other Elements of the Regional Infrastructure

Long distance telephone lines in Alaska are sometimes quite limited outside of major cities. As a result, contacting remote FSSs and NWS offices via long distance is chancy and time-consuming even if toll-free telephone numbers are available (as they are for calling AFSSs). For example, one committee member who was ready to travel from Anchorage to Kodiak was delayed by weather conditions in Kodiak. While waiting for his flight to depart, he visited the airline dispatcher in Anchorage. The dispatcher reported that it was difficult to contact the NWS office in Kodiak, so he obtained his weather information from the National Aviation Weather Advisory Unit in Kansas City, Missouri, and from unofficial sources in Kodiak. During the remainder of the flight delay, the committee member tried telephoning the Kodiak NWS office himself. Over a period of 1 1/2 hours, the circuit was either busy or there was no answer.

Consolidation of FSSs in Alaska will increase the impact of limited long distance telephone capabilities in remote villages by increasing the number of communities that must use long distance telephone calls to contact an FSS. This situation also affects pilots in the air because phone lines often form part of the communications link between en route pilots in remote areas of the state and FSSs.

Cultural Differences

The outlying communities of Alaska attract rugged individuals with a tendency to rely on themselves and do things their own way rather than "by the book." This attitude sometimes manifests itself in aviation, especially when pilots are confronted by a situation that offers only two options: breaking the rules or not flying. For example, many VFR pilots in Alaska tend to fly whether or not they have weather information. As already noted, in many cases adequate weather information is simply not available for their route or destination. However, even if Alaskan VFR pilots are aware of reports of adverse weather information, some of them decide to take off anyway. For many routes and destinations, available weather information is often incorrect or subject to change, so pilots may decide to see for themselves, hoping that the actual weather will be acceptable upon arrival. In addition, FSS pilot briefings for Alaska so often contain the disclaimer that VFR flight is not recommended that this warning has little credibility with most VFR pilots. The frequency of this disclaimer seems to be a reflection of uncertainties in the available aviation forecasts and the government's desire to limit its liability in weather-related crashes of VFR aircraft. However, pilots have learned that weather conditions are often acceptable despite this disclaimer and, as a result, many pilots ignore it, even when the recommendation may be warranted.

Some of the most important factors that determine the safety of a particular flight are the pilot's skill, experience, and willingness to comply with Federal Aviation Regulations, even when the pilot believes that they are overconservative. During their short stay in Alaska, committee members witnessed several instances in which pilots had to assess the weather and decide themselves whether to push the limits—and increase company revenues—or adopt a conservative course of action. The committee saw both types of responses. Because pilots often make these decisions in the air or on remote runways where company management is not in a position to directly influence their decision, air carriers and air taxis that especially value safety must take special care to select pilots who are most likely to value safety and regulatory compliance above expediency.

The Chairman of the Alaska Aviation Safety Foundation—who is a member of this committee—estimates that flight plans are fried for considerably less than one-half of general aviation flights in Alaska.[2] Furthermore, between 1983 and mid-1994, there was no record of a pilot weather briefing for 67 percent of all flights that resulted in an aircraft accident (Berman, 1995).[3] This situation is being exacerbated as local FSSs close or shift to seasonal or part-time status. Many pilots end up flying without obtaining weather briefings or filing flight plans rather than deal with a flight briefer in a distant FSS, especially if they have a hard time making a long distance telephone connection because the lines are busy.

[2] This estimate is consistent with the results of a 1994 survey of Alaskan pilots that was conducted by the Alaska Aviation Safety Foundation and the Aircraft Owners and Pilots Association.

[3] In the other 49 states, during the same time period, there was no record of a pilot weather briefing for 62 percent of all flights that resulted in an aircraft accidents.

Winter weather in Alaska requires frequent plowing of runways to keep them open. It is essential for ground crews to communicate with the FSS network to advise pilots on current runway conditions and warn them when plows are on the runways. Plows are often operated by local residents who speak English as a second language and tend to avoid unnecessary contact with outsiders.[4] However, at many remote runways, there is no one else to report runway conditions. As a result, obtaining current and accurate information on runway conditions is often difficult. For example, the Bethel FSS worked hard to establish good relationships with runway maintenance crews in outlying villages. The closure of the Bethel FSS meant that its responsibilities would be transferred to the AFSS in Kenai, 350 miles to the east. The FSS staff at Bethel doubted that maintenance crews at local villages would effectively communicate runway conditions to the strangers in Kenai.

The harsh weather, difficulty of travel, and relative lack of creature comforts in many towns far from Anchorage discourage federal regulators and other officials from maintaining an effective presence at many remote aviation facilities in Alaska. Although some FSS staff, such as those at Bethel, argued against closing their facilities, this position was not unanimous. Other FSS staff favor consolidation of FSSs in Alaska so they will be transferred out of the outlying communities to an AFSS in a larger community. This desire to leave Alaska's remote communities seems to be a driving consideration for these individuals, and it may contribute to their sense of complacency about how well the system is actually meeting the needs of local aviators.

The FAA's standardized recruiting procedures have discouraged employment of local residents. In addition, these procedures do not include training on localized meteorological conditions for specific FSSs. Greater reliance on local residents to staff FSSs would reduce the relocation expenses that the government currently pays when outsiders are transferred to remote FSS locations. Because of the high cost of transportation in Alaska, these expenses can be substantial.

Economic Factors

Small air carriers and air taxis operating VFR flights essentially decide for themselves whether to dispatch a flight, and it is up to the pilot to determine if weather conditions en route and at the destination meet legal minimums. During periods of low ceiling and visibility, VFR operations cease and passengers and freight accumulate at airports. However, if one airline or air taxi is willing to falsely claim that minimum ceiling and visibility conditions exist, it can initiate flight operations on its own authority. This situation then faces competing air carriers and air taxis with a difficult decision: either they follow suit and operate in unsafe weather, or they lose business. Many prospective passengers are primarily interested in getting to their destination, especially if they do not know enough about the weather to determine for themselves if it is safe to fly or if they assume the government would not allow a commercial aircraft to take off in unsafe conditions. Given a choice between camping out in the airport or getting on an airplane, many passengers will choose the latter option and let the pilot worry about the weather. Furthermore, in the case of two air carriers that have contracts to deliver U.S. mail, the U.S. Postal Service will transfer mail from the airline that is waiting for legal weather to the airline that has chosen to initiate operations in violation of Federal Aviation Regulations.[5] In this kind of economic environment, consistently following the rules can result in bankruptcy.

Individual committee members participated in three flights that took off when reported weather conditions en route or at the destination were either marginal or below the minimum ceiling and visibility required to land. The economic imperatives were so strong that in each case the operators decided that the risk of having to turn back (if weather failed to improve) was worth the chance to complete the flight (if the weather did improve). In all three cases, the flights were completed. However, in one case, the committee member onboard—an experienced pilot—did not necessarily agree that weather conditions were consistently above required minimums. The pilot of this VFR flight almost turned back because of the low ceiling–approximately 500 feet—but he decided to proceed when a pilot ahead of him assured him that weather conditions were satisfactory.

In another case, an airline station manager tried for 2 hours to decide if the weather at the destination airport was satisfactory. Weather conditions at the originating

[4] Those local residents of Native Alaskan ancestry who have a high degree of English fluency and are comfortable working with strangers tend to leave local villages in search of better economic opportunities elsewhere.

[5] Virtually all air freight handled by local air carriers is technically shipped as U.S. mail, because postal subsidies result in mail rates that are significantly less expensive than commercial air freight. (One local pilot recounted spending a week or two transporting a mail shipment of cinder blocks to a village.) In fact, mail is the primary source of income for many small air carriers. As a result, U.S. Postal Service shipping policies exert a strong influence on the aviation marketplace in the outlying communities. Typically, the Postal Service awards several air freight contracts in each town, and it monitors the movement of mail by each contract carrier on a daily basis. If one carrier develops a backlog of 24–72 hours, depending upon the class of mail, then the Postal Service will transfer mail from that carrier to the others if, for whatever reason, they are able to keep the mail moving. In these situations, the Postal Service does not evaluate whether the disparity in service has occurred because of differing levels of compliance with Federal Aviation Regulations regarding minimum acceptable flight conditions.

airfield were free, but his agent reported low clouds and haze at the destination, and the Automated Weather Observing System (AWOS) at the destination reported marginal and worsening visibility. He finally decided to dispatch a flight when his agent reported that a competitor had just landed. It turned out that the weather was excellent throughout the flight, except in the immediate vicinity of the destination, but the station manager had no way to determine en route weather or verify conditions at the destination without dispatching a plane to find out. He could not count on receiving a weather report from the pilot of the competing airline. Even though pilot reports are often the best—or only—source of weather information en route and at outlying destinations, the intense competition evident in the aviation industry serving many local villages discourages public distribution of pilot reports. Commercial pilots tend to radio weather conditions back to their company offices, and this information is not usually distributed to FSSs or other companies.

Although air carriers sometimes train and certify weather observers at their own expense and station them at larger airports to augment weather observations that are otherwise available, each airline tends not to distribute its observations to other air carriers because of competitive pressures and liability concerns. Air carriers want to insulate themselves from any possible liability for weather-related accidents that another airline might experience.

Obtaining up-to-date observations from automated weather stations via telephone is discouraged by the cost of making long distance telephone calls. The station manager for one small airline claimed it had the largest telephone bill in Alaska, largely because of its frequent calls to automated weather stations. He was glad to have an AWOS unit available at one of the air fields he served, and he would like to see AWOS or Automated Surface Observing System (ASOS) units installed at more locations. However, he did not consider calling the local FSS or a central AFSS, which has a toll-free telephone number, to be a timely or effective means for obtaining comprehensive and up-to-date observations from automated weather stations.

Regulatory Factors

Aircraft accidents impact the public, the aviation community, and the FAA. The FAA sometimes increases regulatory enforcement in response to an increase in aircraft accidents. Some Alaskan aviators report that enforcement, however, often seems to focus more on auditing the quality and completeness of airline records rather than the more important but harder-to-address issue of how to prevent VFR pilots from using unsafe practices such as failing to file flight plans or flying below minimum conditions of ceiling and visibility. Unfortunately, it is virtually impossible to legally prove that pilots are flying in conditions below minimums. Even when other pilots or FSS staff observe a VFR pilot taking off into a low ceiling, the offending pilot can claim that he encountered a small break in the clouds that allowed him to depart legally. In fact, some pilots have a reputation for this behavior. If they operate as independent air taxis, there is no corporate authority to restrain such behavior. As already discussed, the inability to enforce regulations effectively means that small air carriers and air taxis that do follow the rules are likely to suffer economically.

Regulations also discourage conscientious pilots who encounter low ceilings or visibility from reporting those conditions accurately. If they do, it is possible for the FAA to impose sanctions for flying below minimums, even for the short time it takes to reverse course or otherwise exit the unsafe condition. Although the FAA does not usually impose sanctions in these situations, making an accurate report places a pilot's license and livelihood in the hands of the FAA and requires a level of trust that sometimes does not exist.

FAA and NWS Organization and Operations

The FAA is highly centralized, and regional FAA administrators have no authority to develop and implement regional solutions to regional concerns. None of the FAA personnel who work at the regional offices reports to the regional administrator except for the administrative and logistics staff. The air traffic services, regulatory, and other professional staff report directly to FAA headquarters. Regional administrators must rely on the cooperation of these staff members if they desire to address regional problems. Regional administrators themselves report to the Associate Administrator for Administration, who is also responsible for budget, accounting, and human resources. Key FAA functions such as air traffic services, regulation and certification, and research and acquisitions are the responsibility of other associate administrators. Although the FAA's centralized organization helps to ensure that FAA policies are uniform throughout the United States, it complicates the process of addressing regional issues. No one below the level of the FAA Administrator has the authority to force resolution of differences that may exist between the staffs of different associate administrators.

Standardization allows procedures developed for and lessons learned in one facility to be adopted immediately throughout the system. Standardization also greatly simplifies the oversight and inspection process. However, a high degree of standardization limits the ability to adapt to varying regional or local conditions, raises costs by pro viding features where they may not be needed, and limits experimentation and innovation (DOT, 1994).

It seems that some aspects of the federal aviation weather system in Alaska are driven more by budgetary considerations than the desire to maximize the safety and efficiency of Alaskan aviation. In some cases, the government has initiated system improvements reluctantly, only after repeated criticism by users, rather than as a result of its own initiative. This is especially true with regard to the location and performance specifications of automated weather systems. In some cases, the FAA has sited AWOS and ASOS units based more on the availability of electrical power and telephone service than on operational aviation or meteorological considerations, and users sometimes have had difficulty in locating (or relocating) ASOS units to provide observations that accurately depict conditions at the location of interest (e.g., the airport runway and approach). Also, as discussed in Appendix E, the NWS stopped commissioning its ASOS units for several months during late 1994 and early 1995 to correct deficiencies in installed units and improve the ability of the NWS logistics system to supply spare parts and complete ASOS repairs in a timely fashion. In addition, the FAA stopped commissioning its ASOS units during 1995 in response to concerns expressed by air traffic controllers about ASOS performance.

The Alaska Regional Office of the NWS, on the other hand, has shown commendable initiative with regard to upgrading aviation weather services. Most significantly, the office is in the process of developing an Alaskan Aviation Weather Unit that, when fully implemented in January 1996, will provide a full-time meteorological center to support Alaskan aviation. The Alaska Regional Office is coordinating the development of this unit with the National Aviation Weather Advisory Unit in Kansas City, Missouri. The Alaskan Aviation Weather Unit will generate weather products that the NWS has not previously generated for Alaska. The Alaska Regional Office plans to deliver these products to FSSs and to NWS offices.

IMPACT OF REGIONAL VARIABILITY ON THE LEVEL OF AVAILABLE INFORMATION

The overall impact of Alaska's regional variability in environmental conditions and user needs is significant. Simply put, in many cases the national aviation weather system is not capable of providing individual pilots and other users in Alaska with the same level of weather information that pilots generally receive in the contiguous 48 states. This is particularly true for VFR flight operations, which include many small, scheduled air carriers and air taxis that provide the only means of public transportation to most of Alaska's communities.

In many respects, IFR operations in Alaska are no different than elsewhere in the United States. Major airports in Alaska have excellent radio navigation and weather reporting systems to support IFR operations during takeoff and landing. En route, IFR aircraft typically fly at high altitudes, so they are unaffected by low-altitude weather conditions. (The major exception, as previously noted, is the prevalence of freezing levels at or below 7,000 feet. This often prevents small aircraft that are susceptible to icing from flying above the weather, even if they are instrumented for IFR flight operations.) However, there is sometimes an imbalance between aviation weather and navigation systems. Air carriers find it necessary to supplement federal aviation weather services by providing their own certified weather observers at some airports—including the state capital of Juneau—where the level of economic activity justifies the additional expense. This remedy is not economically feasible for air fields at small communities that have radio navigation systems but lack the certified weather observations needed to satisfy regulatory requirements for IFR flight operations. As a result, the radio navigation systems at these airfields are of minimal utility.

As already noted, many regions of Alaska experience rapidly changing weather patterns. FSSs typically were built at airports with unobstructed views of the runway. This helped mitigate the impact of changes in the weather, especially at airports with no control towers. However, FSSs are closing at many airports. It will be difficult for remote AFSSs to provide the same level of detailed, upto-date information previously supplied by FSSs.

Most of the small villages in Alaska have no certified weather observations (from human observers or automated systems). As a result, the air carriers and air taxis that service these destinations have established informal sources for weather information to help them decide if the weather conditions (e.g., ceiling and visibility) at the destination will allow a safe landing. Each operator typically uses its own local business agents to provide this information. Because most of these observations are produced by untrained observers working without instruments, there is a good deal of variability between the observations reported by different operators. During marginal weather conditions, the level of variability may be enhanced if one operator's business agent is especially eager for a flight to get through. Agents sometimes report that visibility, ceiling, or runway condition are better than they really are if they are waiting for delivery of a paycheck, relative, or shipment of groceries that may have been sitting in an airport for several days waiting for the weather to clear.

As noted in Appendix E (page 83), "FAA policy is that the performance of combined automated systems must be equal to or better than manual observation capability" (FAA, 1994). However, Alaskan aviators—like many aviators in the rest of the United States—generally view automated observations as a poor substitute for human observations. Currently available automated surface weather observing systems (i.e., AWOS and ASOS) cannot accurately describe some meteorological conditions of interest to aviators. ASOS, which is more advanced than AWOS, cannot detect or report the presence of weather phenomena such as thunderstorms, hail, volcanic ash, snow fall, snow accumulation, or ground fog (NOAA, 1993). ASOS and AWOS also cannot distinguish localized or directional weather conditions. For example, automated systems sometimes report clear visibility if visibility overhead is clear, even though horizontal visibility along the ground (from blowing snow) is almost zero. These systems also cannot characterize specific conditions over airport approaches: they cannot report that ceiling and visibility are adequate to approach a runway from one direction, but low clouds are obscuring the approach from the other direction. The same situation occurs in mountain passes, where pilots need specific information about weather conditions along the flight path. In these situations, having an untrained human observer can be more valuable than having an automated system.

Automated systems have a reputation for unreliability and inaccuracy among many users interviewed by the committee, and the committee encountered some NWS staff at Alaskan field offices who shared this assessment. Furthermore, there is usually no way for individual users to determine the accuracy of individual readings, so users end up questioning the accuracy of virtually all automated observations. During its stay in Alaska, the committee encountered several local users, including an NWS meteorologist, who reported their personal frustration with automated observing systems that generated ceiling, visibility, and/or wind speed readings that were inconsistent with visual observations. For example, aviation weather users in Bethel noted that the AWOS unit at Hooper Bay suffered from a dirty lens. This unit would report visibility of 0.75 miles, even though actual visibility exceeded 10 miles. The automated station at St. Marys was also malfunctioning—a committee member verified that telephoning the St. Marys station was useless because the audio report was unintelligible. Another committee member observed the AWOS unit in Barrow produced wind readings that varied by as much as 20 miles per hour from NWS readings taken with traditional weather-station observing equipment. This unit also reported several cloud layers when the observed sky was clear. Based on their past experience, local users did not expect these problems to be corrected in a timely fashion.

Despite such problems, users generally do believe the trends shown by automated stations. During marginal weather, a dispatcher may telephone the destination's automated weather station every few minutes to assess ceiling and visibility trends while talking to the agent at the destination to get a human perspective.

Also, users value automated systems that have been installed at locations that previously offered no weather observations. These systems are a valuable source of basic data such as temperature, altimeter settings, and wind speed and direction, and they produce official weather reports to meet regulatory requirements for IFR operations.

OPTIONS FOR IMPROVING REGIONAL SERVICES

Most of the unmet needs of Alaska users of aviation weather services concern the observation and dissemination of weather information. Options for improving observations and dissemination are listed in the following sections. Each of these options has advantages and disadvantages. None, by itself, will fully respond to current needs. Chapter 5 discusses a process by which the FAA can take the lead in working with the NWS, responsible federal and state government agencies, the aviation industry, airport operators, pilots' professional organizations, and local communities to agree on an appropriate plan of action.

Weather Observations

In remote and mountainous regions, the primary operational weather need is for more low-level en route and terminal weather observations and forecasts. Options for increasing the availability of certified weather observations in Alaska and other regions with special needs include the following:

- Increase the role that states play in providing weather observations.
- Train more certified human observers. Possible sources include airport maintenance workers, resident airport managers, Air National Guard units, state patrol offices, emergency medical technician units, village public safety officers, or other local village residents. It might also be feasible to set up a volunteer organization modeled after volunteer fire departments to provide this service.
- Establish one or more classifications of weather observers who would be trained and certified to provide partial weather observations (see Chapter 3, page 24). These observers would be able to provide

essential information such as ceiling, visibility, temperature, barometric pressure, runway condition (at airport locations), and precipitation.

- Establish a network of informal weather observers. Uncertified observers could make "ground reports" just as pilots, who are generally not certified to make official weather observations, currently make pilot reports.
- Make better use of NWS staff, tower controllers, and flight service specialists assigned to airfields in remote locations. At locations where the workload does not justify the existence of a separate NWS field office, airport tower, and FSS, it may be feasible to establish a joint office with a multidisciplinary staff to provide a mix of services tailored to the needs of the local community.
- Increase the use of local residents as weather observers and flight service specialists. Local residents are familiar with local weather patterns, and they do not feel as isolated from the outside world as many outsiders do when they are transferred to remote duty stations.
- As an alternative to maintaining the few remaining FSSs in outlying areas, implement a more-numerous system of mini-FSSs modeled after the Community Aerodrome Radio Stations that Canada operates in northem Canada to take weather observations, file local airport advisories, provide en route weather information, and pass en route position reports. These stations also offer walk-in weather information and flight planning services. They do not provide formal pilot briefings or file flight plans, but these services are available by phoning the nearest FSS. The stations are contractor-operated facilities, which reduces their costs, and many of them are staffed by local residents who are formally trained and certified as weather observers and radio operators.
- Extend the hours that contract observers make observations.
- Encourage better use and reporting of pilot reports by general aviation and scheduled air carrier pilots, perhaps by implementing an incentive program.
- Implement a system of collecting synoptic weather observations from air carrier pilots on selected routes.
- Pass a "good Samaritan" law at the state level to absolve from liability individuals who provide informal weather observations in good faith.
- Install more automated weather observing units. For example, current plans call for installing AWOS and ASOS units at 100 sites in Alaska. However, most of the state's 450 airfields will still lack automated (or human) certified weather observations.
- Augment ASOS and AWOS units at selected destinations and key en route points with video cameras to provide flight service specialists, pilots, and flight dispatchers in local communities with an up-to-date view of the observation site. This would enable remote users of automated observing systems to examine the location, extent, direction of motion, and type of cloud conditions in the vicinity of the observing site. Video cameras would also allow users to validate the objective data produced by automated weather stations subjectively.[6]
- Establish a system to repair automated weather observing units more quickly when they malfunction, and, if immediate repair is impossible, to allow manual observations to override the automated system until repairs can be made.

Dissemination

The efficient dissemination of accurate weather information is also a key concern in regions with special needs, especially for VFR pilots. Options to improve dissemination include the following:

- Maximize radio and television broadcasting of aviation weather programs produced by local public television stations.
- Increase the number of radio navigation beacons that transmit transcribed aviation weather information.
- Establish a system of wide-coverage VHF repeaters to disseminate transcribed aviation weather information.
- Establish a dedicated weather broadcast network to relieve the demand on FSS operators for weather information and provide preflight weather information via handheld aviation transceivers.
- Establish a broad-area satellite radio broadcast to transmit current weather information.
- Routinely distribute relevant weather maps by telefax, especially to airline and air taxi dispatchers in outlying areas.

[6] For the past 25 years, Valdez has had a video camera to monitor maritime and aviation traffic in the approach and departure corridor to Valdez. This camera is a valuable asset that has allowed flight service specialists to estimate ceiling and quadrantal visibility. (The monitoring station for this camera was relocated from Valdez to Cordova when the FAA closed the Valdez FSS. It was then moved to the Juneau AFSS when the Cordova FSS closed.) Also, the NWS's regional office for Alaska is evaluating a year-long test of a remote video camera system that the Weather Forecast Office in Salt Lake City, Utah, is using to augment the ASOS unit installed at the airport in Logan, Utah. The NWS has used this system to monitor weather conditions outside the immediate vicinity of the ASOS and to verify ASOS operability when forecasters questioned the accuracy of data transmitted by the ASOS. As such, the video system provides two key capabilities that are lost when human observers are replaced by automated observing systems.

- Distribute high-quality satellite imagery received by the NWS to FSSs and other users to make appropriate use of this resource.
- Reprogram dissemination systems to retain and report data, including pilot reports, long enough for users to determine trends en route and at their destinations. For some remote regions, it may be prudent to retain data for extended periods of time (with the caveat that it may be out of date) rather than to dump old data as soon as it exceeds a preset retention period. Routine purging of data may make sense in a data-rich environment, but it can be counterproductive in regions where the primary source of information is unscheduled observations, such as pilot reports.

In the Alaskan aviation community, hand-held VHF aviation transceivers are more common than modem-equipped computers. Thus, in regions such as Alaska, information dissemination schemes that rely on radio transmissions are more likely to be widely useful than computer-based systems such as the Direct User Access Terminal Service.

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Appendix J

Alternative Approaches for Improving Aviation Weather Services and Research

National policy makers have numerous options for altering agency roles and missions in ways that might improve the ability of the federal government to provide aviation weather services and provide related research. They range from maintaining the status quo to making radical changes. The committee evaluated seven alternatives that, in the opinion of the committee, encompass the most feasible and reasonable possible courses of action:

1. Maintain the status quo.
2. Maintain the status quo, with a senior focal point within the Federal Aviation Administration (FAA) for aviation weather.
3. Shift additional federal responsibilities for aviation weather services and related research to the FAA.
4. Shift additional federal responsibilities for aviation weather services and related research to the National Weather Service (NWS).
5. Establish a new organization to provide aviation weather services and conduct related research.
6. Assign primary responsibility for aviation weather operational services and related research to two different agencies.
7. Increase the effectiveness with which the FAA serves as the lead agency for aviation weather services and related research.

These alternatives form the basis for the committee's recommendations on future agency roles and missions for aviation weather. The first six alternatives are described below. Alternative 7, which the committee recommends implementing, is described in Chapter 6 (page 52).

Alternative 1. Maintain the status quo. The current system would continue to operate with no changes in agency roles and missions.

Advantages. Accepting the status quo would, by definition, eliminate the trouble and expense of making changes to the deeply imbedded organizational cultures and management structures of federal agencies involved in aviation weather and research. Furthermore, simply doing a better job of following current policies, such as the existing memorandum of agreement between the FAA and the National Oceanic and Atmospheric Administration (NOAA) for aviation weather services (FAA, 1977), is likely to improve aviation weather system operations. Similarly, carrying out recommendations contained in this report and in other documents, such as the *U.S. Weather Research Program Implementation Plan* (USWRP, 1994), the *National Aviation Weather Program Plan* (OFCM, 1992), and *Weather for Those Who Fly* (NRC, 1994), would improve aviation weather research and development without any realignment of agency roles and missions. In addition, federal agencies could improve their ability to carry out their currently assigned roles by working more closely with each other and by establishing more effective bilateral and multilateral relationships to coordinate and plan aviation weather services and related research.

Disadvantages. Accepting the status quo misses the opportunity to seek more substantial improvements in aviation weather services. In particular, it does not adequately address concerns regarding program focus, interagency coordination, and leadership. As a result, the setting of aviation weather priorities for operational services and related research would remain fragmented among and within federal agencies and their respective congressional committees.

Alternative 2. Maintain the status quo, with a senior focal point within the FAA for aviation weather. The current system would continue to operate with no changes in agency roles and missions. However, an FAA associate administrator would be given overall responsibility for coordinating and overseeing the planning and implementation of aviation weather services and related research within the FAA. This official would also coordinate the timely development of agency-wide responses to existing and future aviation weather issues. This means that one person would accept a sense of ownership for the effectiveness of the FAA's aviation weather system.

Advantages. As discussed under Alternative 7, developing a single FAA position on broad aviation weather issues sometimes involves the offices of several FAA associate administrators. Officials from the NWS, other federal agencies, and user groups are often frustrated when they try to resolve aviation weather issues because there is no single point of contact within the FAA who can bring issues to closure. Therefore, in addition to the advantages described under Alternative 1, this alternative would (1) improve aviation weather leadership and focus within the FAA, (2) improve the FAA's ability to resolve aviation weather issues in a timely fashion, (3) reduce the frustration currently experienced by outside agencies and the private sector when attempting to resolve aviation weather issues with the FAA, and (4) facilitate efforts by the FAA to carry out its existing memorandum of agreement with NOAA.

Disadvantages. Alternative 2 shares most of the disadvantages listed for Alternative 1. Although Alternative 2 would improve leadership within the FAA regarding the provision of aviation weather services, it does not address interagency issues.

Alternative 3. Shift additional federal responsibilities for aviation weather services and related research to the FAA. The FAA would be assigned greater responsibility for providing aviation weather services, including some or all of those now provided by the NWS, the National Aeronautics and Space Administration (NASA), and other civilian agencies. Thus, this alternative actually encompasses a range of options, depending upon the extent to which aviation weather functions are transferred to the FAA from other agencies.

Advantages. In the extreme case, the FAA would assume complete responsibility for directly providing aviation weather services. This would clearly consolidate within a single agency complete responsibility for providing needed leadership, focus, and prioritization for aviation weather services and related research. This would also give the FAA administrator direct control of the assets needed to improve aviation weather services and enhance the safety and efficiency of the national airspace system. More restrained versions of this alternative would share this advantage, although not to the same degree.

Disadvantages. The FAA does not currently possess the meteorological facilities or personnel needed to significantly increase its direct responsibility for providing aviation weather services and related research. This alternative would also create the need for the FAA to provide functions that the NWS currently provides. Doing this would involve transferring personnel and equipment from the NWS to the FAA. However, the NWS would need to retain some of the facilities and personnel that support aviation weather because they also support nonaviation meteorological services. Thus, the FAA would probably need to duplicate some of the functions that the NWS would retain.

With regard to research and development, the FAA does not have the scientific personnel and facilities to conduct the type of basic and applied research programs that NOAA and NASA currently conduct in support of aviation weather. Also, because many of the research programs in NOAA and NASA also support atmospheric science research that has widespread application beyond aviation, consolidating research and development within the FAA would also increase interagency duplication of effort.

Alternative 3 might foster a long-term roles and missions dispute among involved agencies, and approval would require concurrence by numerous congressional committees to reallocate federal responsibilities. Also, even if this approach improved aviation weather services, the duplication of services would increase overall costs. Thus, for budgetary and other reasons, this alternative seems impractical.

Alternative 4. Shift additional federal responsibilities for aviation weather services and related research to the NWS. This option is identical to Alternative 3, except that civil aviation weather services would be consolidated (wholly or in part) within the NWS rather than the FAA.

Advantages. Alternative 4 would increase the extent to which responsibility for aviation weather resides within the meteorological community. As a result, it would facilitate improvements to meteorological functions and weather products associated with aviation weather.

Disadvantages. Because of the NWS's inherent focus on meteorology, this alternative might reduce the extent to which new aviation weather services and products support nonmeteorological users of aviation weather information (e.g., pilots, dispatchers, and air traffic controllers). As discussed in Chapter 3 (pages 38 and 39), aviation weather services would benefit from a greater focus on user needs, which this approach is unlikely to provide.

Transferring some or all of the FAA's aviation weather responsibilities to the NWS would involve the transfer of appropriated funds from the Department of Transportation/FAA to the Department of Commerce/NOAA/NWS. Aviation weather would then compete for these funds against other interests within the Department of Commerce. The overall level of aviation weather activities would suffer if federal or congressional authorities redirected some of the transferred funds to support these other interests.

Alternative 5. Establish a new organization to provide aviation weather services and conduct related research. The government would establish a new federal agency, federal corporation, or private corporation to take the lead in providing aviation weather services and conducting related research.

Advantages. This radical change to the existing system would result in a new entity that is totally committed to aviation weather. Such a change would diminish involvement in aviation weather by the FAA, NWS, and Office of the Federal Coordinator for Meteorology. Conceivably, this arrangement could ultimately provide a more cost-effective system, particularly if it departs from standard government personnel and procurement practices. Implementation of this option could be addressed as part of the ongoing debate regarding the possible transfer of some FAA functions to a private or federal corporation.

Disadvantages. Even more than alternatives 3 and 4, this proposal involves major changes in agency structures, shifts in the oversight responsibility of congressional committees, and fundamental changes in budgetary allocations. Making changes of this scope could take years to achieve and, in the end, it might not succeed. Meanwhile, other alternatives with a higher probability of success would be held in abeyance.

A new organization seems likely to increase the management overhead associated with aviation weather services. Establishing a separate aviation weather agency also shares many of the disadvantages associated with increasing the concentration of aviation weather within the FAA or NWS (alternatives 3 and 4, respectively). The new agency would tend to duplicate functions retained by the FAA and NWS, diminish the ability of the FAA to improve aviation safety and efficiency, and probably increase overall costs.

Alternative 6. Assign primary responsibility for aviation weather operational services and related research to two different agencies. Alternative 7 could be modified to allow NOAA or NASA to assume primary responsibility for coordinating and overseeing the planning and execution of aviation weather research by the federal government. The FAA would assume primary responsibility for aviation weather services, as described in Alternative 7.

Advantages. The FAA is an operational agency that does not have the same depth of scientific research expertise and facilities that NOAA and NASA possess. The FAA already funds NOAA laboratories to conduct a great deal of aviation weather research, and NASA is much more focused on research and development as an institutional mission than is the FAA. As such, these agencies are generally better suited to conduct research programs than is the FAA.

Disadvantages. The utility of aviation weather services and systems is a strong function of the extent to which they satisfy user needs. As noted in Chapter 4 (page 46), the committee recommends establishing closer ties between aviation weather research programs and users. Splitting the management of aviation weather operations and research between two agencies does not contribute to achieving this objective. Also, making the FAA responsible for overall coordination of aviation weather research should not diminish its reliance on agencies such as NOAA and NASA to plan and implement specific research efforts in accordance with overall goals established by the FAA.

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