National Aviation Weather Program Mid-Course Assessment

Accident Reduction Trends Confirm Value of Coordinated R&D Programs

Prepared by the

Office of the Federal Coordinator for
Meteorological Services and Supporting Research

for the

Federal Committee for Meteorological Services
and Supporting Research

and the

National Aviation Weather Program Council

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Foreword

This mid-course assessment gives me both cause to celebrate and cause to renew and re-energize our efforts to reduce the weather-related risks to aviation safety. I can celebrate because *we are making real progress*. The analyses confirm much anecdotal evidence that the coordinated efforts and diverse partnerships that constitute the national aviation weather program initiatives are making a real difference in accident rates. The investments in research and development (R&D) and implementation of products, services, and systems are paying off. But we have not yet reached our goal. If we fail to sustain the efforts so effectively started, the trends charted here will not be sustained. A national safety goal that is within reach could slip from our grasp. This assessment tells us where trouble spots remain and points to ways we can overcome them, while furthering the work that has started us toward success.

In 1995, a study committee of the National Research Council called for coordinated federal action to improve weather services for aviation users and strengthen the R&D base required for sustained improvement. The committee's report, *Aviation Weather Services: A Call for Federal Leadership and Action*, correctly identified the Federal Aviation Administration as the lead agency for this coordinated effort. It also noted where the roles and missions of other federal agencies and the private sector gave them shared responsibilities as well as opportunities to contribute.

The framework for an invigorated and coordinated national effort in aviation weather was established in the 1997 *National Aviation Weather Program Strategic Plan*. This document identified strategic elements and defined the roles and missions of participating federal agencies with respect to those elements, while delegating implementation of the plan to the agencies and their university and industry partners. A second tier of coordination was established by *National Aviation Weather Initiatives* in 1999. Both of these documents were prepared by the Joint Action Group for Aviation Weather and approved by the National Aviation Weather Program Council, which is chaired by the Federal Coordinator.

The Aviation Weather User Forum in 2000 set the stage for strong partnering among the federal agencies, the aviation community, and the commercial sector that serves the aviation community. This forum also provided a starting point for the Office of the Federal Coordinator for Meteorological Services and Supporting Research to begin compiling details of individual projects and their relationship to the national aviation weather initiatives established the preceding year. The forum provided many examples of partnerships between the public and private sectors, as well as among federal agencies, that were producing results with evident benefits for users. The first compilation of this project-level data was released as the *National Aviation Weather Initiatives Final Baseline Tier 3/4 Report* in 2001.

The aviation industry has continued to play a strong role in the national programs and initiatives as well as having the principal role in commercializing and using the resulting technology. The university research community has contributed greatly to aviation weather R&D. Aviation associations and others serving the aviation community (university-based and commercial providers) have played a major role in education, training, and outreach. The positive consequences of these efforts are already evident in the declining trends for weather-related accidents in general aviation, which are analyzed in this report. Without the broader partnerships into which associations, universities, and the aviation industry have entered with the agencies participating in the National Aviation Weather Program Council, the successes we can now document would not have happened.

We are at a midpoint in the original ten-year effort—a good perspective from which to assess where progress is being made and where more attention may be needed. In my roles as the Federal Coordinator and Chair of the National Aviation Weather Program Council, I will use this mid-course assessment, plus the Tier 3/4 review and analysis process, to coordinate continued progress in our national aviation weather program initiatives.

I intend to work with the agency partners in the Federal Committee for Meteorological Services and Supporting Research, the National Aviation Weather Program Council, and the Committee for Aviation Services and Research to ensure that these areas receive appropriate attention. In particular, I want to thank the Chair and members of the Committee for Aviation Services and Research for supporting this mid-course assessment.

Samuel P. Williamson
Federal Coordinator for Meteorological Services
and Supporting Research

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Executive Summary

This report presents a mid-course assessment of progress toward the goal of reducing weather-related fatal accidents by 80 percent over ten years. In February 1997, the White House Commission on Aviation Safety and Security recommended an 80 percent reduction in fatal aviation accidents from all causes as a ten-year national goal. In its 1999 report on *National Aviation Weather Initiatives*, the National Aviation Weather Program Council identified initiatives being pursued by federal agencies in collaboration with their industry and university partners. The *Initiatives* report also discussed an 80 percent reduction in weather-related accidents as an overall measure of success. To assess progress toward this goal, this report examines trends in weather-related accidents for clearly defined categories of aircraft and weather hazards. In each category, an 80 percent reduction from the average accident rate just before and during 1997 is used as a benchmark for assessing success in reducing accident risk.

Accident Risk and Weather Hazard Analysis

The accident risk analysis uses accident data from the National Transportation Safety Board (NTSB). Federal Aviation Administration (FAA) estimates of total departures or total flight-hours are used to calculate accident rates from the NTSB accident counts. The aviation community is divided into three categories used by the NTSB: major air carriers (aircraft regulated under Part 121 of the Federal Aviation Regulations), smaller aircraft in revenue service (regulated under Part 135), and general aviation (regulated under Part 91).

For all three regulatory categories taken together, the average number of weather-related fatal accidents in the base years for determining the 80 percent reduction goal (1994–96) was 112. In 2001, the number of weather-related fatal accidents was 45, and the three-year moving average (1999–2001) was 70. On this broad basis, substantial progress has been made toward the goal of an 80 percent reduction (no more than 22 fatal accidents per year in all categories). But the goal has not yet been reached, and continuation of ongoing efforts is essential to reach it by 2006. To direct these efforts, the mid-course assessment has examined the accident experience over time in each of the three aviation categories and, within them, the success in reducing the risks from specific weather factors.

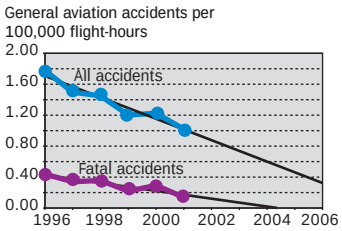
Weather-related fatal aviation accidents decreased from an average of 112 per year in 1994–96 to just 45 in 2001.

Fatal weather-related accidents for the major air carriers are too infrequent (only two accidents from 1995 through 2001) to assess statistical trends. However, if the data for *all* weather-related accidents are used as an indicator, further improvement will be needed to reduce the weather-related accident rate for major carriers by 80 percent. The category of weather hazards that contributes most to these accidents includes turbulence and convection hazards (such as microbursts, downdrafts and updrafts, gusts, or wind shear).

A major piece of good news from the hazard assessment is the steady decline since 1996–97 in weather-related

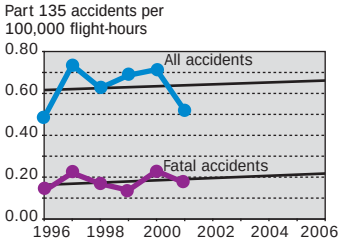
Weather-related accidents—fatal and nonfatal—for general aviation are on strong downward trends. With continued investment and support from all partners, an 80 percent reduction can be achieved for this aviation category by 2007.

accidents for general aviation aircraft (Part 91). The trend for fatal weather-related accidents for all weather factors is on track to exceed the 80 percent reduction benchmark, as is the trend for fatal accidents in five of the six weather hazard categories used in this report.



Only the category for temperature and lift hazards for Part 91 is not on trend to achieve an 80 percent reduction. The weather factor that dominates this category, for both general aviation and smaller air carriers, is *high density altitude*. This flight performance factor takes into account the effect of temperature on the amount of air flowing over the camber of an aircraft's wing, particularly during takeoff and landing at higher elevations. High humidity in hot weather exacerbates the effect by decreasing engine performance.

The accident data for smaller air carriers in revenue service (Part 135 aircraft) are not yet on clear downward trends. In fact, the rate trends for all weather-related accidents and for fatal weather-related accidents for Part 135 are nearly flat to slightly increasing. The analysis by weather hazard category indicates that the fatal accident rates for these aircraft in four of the six hazard categories are not trending down enough to achieve an 80 percent reduction target. In two categories—precipitation (non-icing) hazards and icing conditions—the trends are increasing. In all six categories, the data series for all weather-related accidents confirm a general pattern: accident rates for Part 135 aircraft are not yet trending toward the reduction benchmark.



Mid-Course Assessment

In 2001, the *National Aviation Weather Initiatives Final Baseline Tier 3/4 Report* presented a project-by-project review of the efforts recently implemented or in development on each of the national aviation weather initiatives identified in the 1999 report. Section 4 of this report begins with an updated overview of these projects, organized by lead partner and by five categories of principal product type: weather product development; weather product dissemination; education, training, and outreach; cockpit displays; and decision support systems and capabilities.

Section 4 then assesses this portfolio of programs and projects in relation to the noteworthy trends in accident rates noted above. Sections 4 and 5 develop the following conclusions and recommendations for achieving the 80 percent reduction goal for fatal aviation accidents.

Sustaining Risk Reduction Success in General Aviation

The limited evidence available suggests that a combination of factors underlies the strong downward trends in weather-related accident rates for general aviation. These factors include:

1. The revolution in weather information products flowing from the National Weather Service Modernization in the 1990s
2. The aviation-specific systems and products whose development and implementation have been sponsored and funded by the FAA through its Aviation Weather Research Program (as well as various predecessor and coordinated programs)
3. Advances in information communication systems and weather product dissemination services, which have given general aviation pilots access to these improved products and services
4. Acquisition by general aviation pilots of the knowledge needed to use the available information to avoid hazardous weather conditions.

Education and training for the general aviation pilot is the linchpin that ties together the first three factors into a success story. Statistics from the Aircraft Owners and Pilots Association on course attendance and video seminar sales support anecdotal information from association staff on the positive response of the general aviation community to improved access to weather information products and services. The popularity of the Aviation Digital Data Service (ADDS) website shows that the aviation community is embracing the use of improved aviation weather products.

Conclusion 1. The partnerships through which aviation and weather associations, the aviation industry, and federal agencies have provided education, training, and out-

reach to the general aviation community have made a strong beginning in reducing the risks of weather-related accidents in the Part 91 aircraft regulatory category. The ambitious goal of an 80 percent reduction in the fatal accident rate for general aviation appears attainable by 2006 if these efforts can be expanded to reach every general aviation pilot. The general aviation community will also need to know about new products and services that are becoming available, such as those resulting from university-based research and development (R&D). The development and implementation programs for these new products and services must be sustained, despite fiscal constraints and tight budgets.

Recommendation 1. The partnerships for education, training, and outreach should be expanded to include more collaboration among entities offering courses and materials. The aim should be to provide every general aviation pilot with knowledge of all weather hazards that the pilot is likely to encounter, together with the information and advisory services to deal with them safely. To sustain the accident reduction trends, these education and outreach efforts must keep pilots informed about the new products and services emerging from R&D to the implementation phase.

Reducing Accident Trends for Smaller Commercial Carriers

For aviation weather technology to make a difference for smaller carriers in revenue service (Part 135 aviation), the information from these advances in weather observation and forecast products must be delivered to the Part 135 pilot. Furthermore, these information dissemination solutions must fit within the cost constraints under which Part 135 aviation services operate. The FAA Safe Flight 21 program is a promising initiative that could meet these challenging requirements. As already demonstrated in the Alaskan Region Capstone program, Safe Flight 21 will include a communications uplink capability, Flight Information Services–Broadcast (FIS-B). FIS-B can deliver current weather information to the cockpit, viewable on the same multifunction display the pilot will use for traffic awareness and terrain visualization in all visibility conditions. Although FIS-B appears to offer a long-term solution for getting current weather information en route, along with terrain visualization, to the Part 135 pilot (as well as to general aviation pilots) at affordable costs to the industry, most of the National Airspace

Many Part 135 aircraft are smaller planes, like this commercial carrier of passengers and cargo in Alaska. Photo courtesy Wings of Alaska Airlines, © Mike Mastin.

System will not have FIS-B coverage until after 2007. Thus, the program's major impact on weather safety will not be felt until after the 2006 milestone for achieving the 80 percent accident reduction goals.

Because of the diversity of operations and services that are regulated under Part 135, a more detailed analysis for this category is needed of the weather factors involved in weather-related accidents, grouped by similar types of aviation service. The detailed analysis should include an assessment of aviation weather program elements, including both R&D and implementation efforts, that can lessen the risks identified for specific segments within the Part 135 aviation category. In the interim, the Part 135 community needs to be well informed about the weather information sources already available or nearing implementation.

Part 135 includes aircraft used for contract services that require flying in hazardous weather, such as medical evacuation and emergency rescue flights. Photo courtesy Air Ambulance Specialists, Inc.

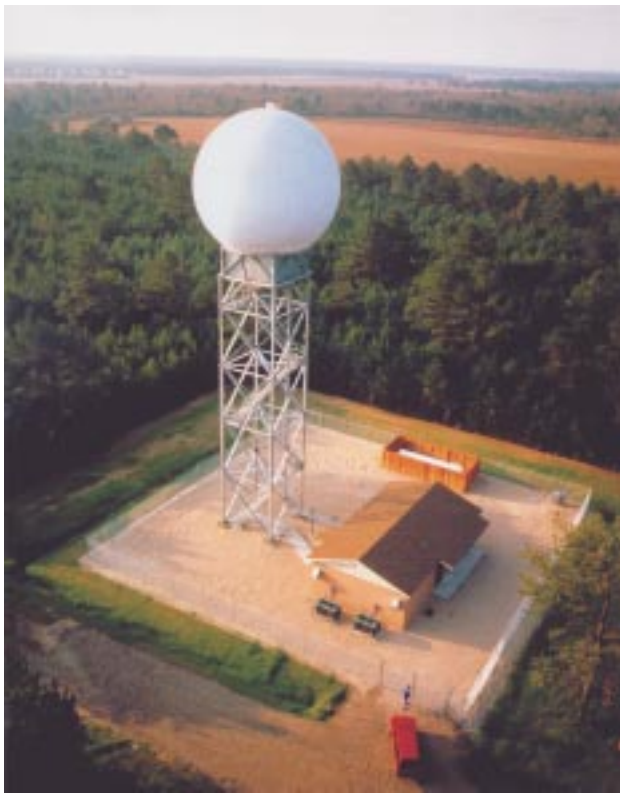
Conclusion 2. Part 135 aviation is constrained by factors that distinguish it from either general aviation or major commercial carriers. The range of operations and types of services offered in this category vary widely and include some that are inherently more hazardous than general aviation or commercial air carrier flights. Early results from the Alaskan Region Capstone demonstration, part of the FAA's Safe Flight 21 program, indicate that the technology exists to lower weather-related accident risks for at least some Part 135 operations. Unfortunately, the current deployment schedule for Safe Flight 21 will not provide weather information coverage across most of the National Airspace System until the 2007–12 time frame. A more detailed analysis of weather-related accidents involving Part 135 aircraft will be needed to determine how different segments of this diverse category are affected by various weather hazards and what actions could be taken to lessen the risks and reduce accident rates.

Recommendation 2. A more detailed analysis, probably employing a case analysis approach, should be conducted to assess the impact of weather hazards on specific segments of the aviation community regulated under Part 135. As an interim measure, a special effort should be made to ensure that both pilots and owners of Part 135 aircraft are aware of the weather information infrastructure and services available to them.

- Prior to deployment of Flight Information Services–Broadcast under the Safe Flight 21 program, available information sources and services, such as the Aviation Digital Data Service and the Flight Information Services Data Link, can be emphasized in the outreach program.
- As the Flight Information Services–Broadcast becomes available via the Safe Flight 21 Universal Access Transceiver communications uplink, training in this information service should be emphasized.

Reducing Risk from Turbulence and Convection Hazards

Turbulence and convection hazards account for substantially more than half of all weather-related accidents each year involving aircraft of the major air carriers. Although very few of these accidents cause fatalities, weather factors in this hazard category are cited each year in multiple fatal accidents involving general aviation and smaller



The FAA has installed Terminal Doppler Weather Radar at high-activity airports to detect weather hazards for departing and landing aircraft. Photo courtesy FAA.

commercial carriers. For both en route and departure/landing service areas, a number of projects in progress can contribute to reduce the risks from these hazards.

The Graphical Turbulence Guidance product for aviation forecasters is now implemented for flight levels down to 20,000 feet. The FAA's Aviation Weather Research Program plans to include guidance for turbulence down to 10,000 feet, which will increase its value for Part 135 and general aviation flights. Observational data on in-flight turbulence from the In-Situ Turbulence Algorithm is planned for implementation on a limited number of commercial aircraft by incorporating it into their Aircraft Condition Monitoring System. The automated data download via this system will eventually help to improve the Graphical Turbulence Guidance product and validate turbulence prediction models used by aviation weather forecasters. Methods for detecting clear-air turbulence ahead of commercial aircraft are also being researched.

Several observing systems already in limited deployment at the nation's airports provide air traffic controllers, traffic managers, and flight service station specialists with information about these weather hazards in the terminal area and surrounding airspace. Among these are the FAA's

Weather System Processor, Medium Intensity Airport Weather System, Terminal Doppler Weather Radar, and improved Low Level Windshear Alert System. Models and other forecasting tools for nowcasts (predictions for current conditions to a few hours in the future) will aid in predicting when and where these hazards may be encountered. Flight information services uplinks and other information dissemination systems will help deliver alerts to pilots in near-real time.

Continued investment in these R&D and implementation programs is essential to reaping the benefits they offer for reducing aviation risks from turbulence and similar wind hazards. The risk from these hazards in all three aircraft regulatory categories shows that completion of the work in progress is a worthwhile R&D investment for the nation.

Conclusion 3. No single sensor system or forecast improvement will address the entire range of conditions, both en route and in the terminal area, that produce turbulence and convection hazards. Nevertheless, a sustained effort can put new technology in place, assess its effectiveness, and ensure full implementation of products and services with proven efficacy. A number of programs that are likely to improve detection, forecast, and warnings about these hazards are in or nearing the implementation stage.

Recommendation 3. Investment should continue in R&D and implementation on projects that will contribute to timely observations, forecasts, and warnings of turbulence and convection phenomena, both en route and near the terminal area.

Reducing Risk from High Density Altitude

The factors that contribute to accidents involving high density altitude are well understood. If general aviation and Part 135 pilots have accurate information about temperatures and relative humidity in their departure and landing patterns, they can use the performance parameters of their particular aircraft and flight load to calculate and compensate for the density altitude. Thus, this weather hazard can in principle be avoided. However, the rate trends for accidents in which high density altitude is cited indicate that pilots are still having problems with the multifactor computations and considerations required to avoid density altitude problems.

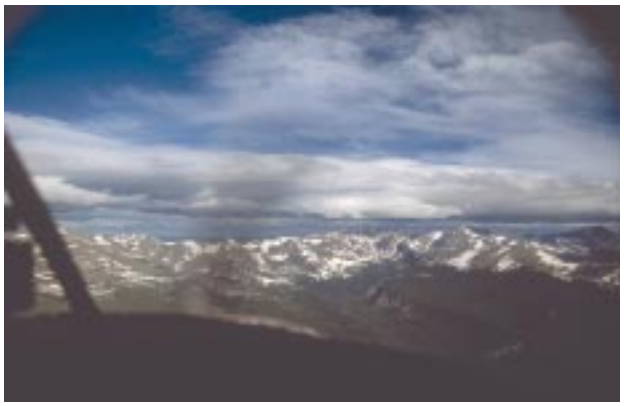
Conclusion 4. The hazard of high density altitude can be addressed, if the pilot has accurate observations or forecasts and a decision support tool that receives this information and combines it with the specifications and running condition of the aircraft. The pilot must also have the training to understand the implications of advice or guidance provided by this decision support capability.

Recommendation 4. A review should be undertaken of the circumstances contributing to aviation accidents in which the National Transportation Safety Board has cited high density altitude as a factor. This review should assess the tools currently available to Part 91 and Part 135 pilots to assess density altitude and related aircraft performance parameters, as well as the weather information products, decision support capabilities, or education and training resources that could be provided or improved to reduce the risk from this weather hazard.

Risk Reduction for Other Weather Factors

The annual statistics on weather-related aviation accidents identify a number of additional weather factors that are cited each year in multiple accidents, particularly for general aviation aircraft. Although the frequency of citation for these factors is on a downward trend for the reporting period analyzed in this assessment, sustaining these trends will require continued support for programs and initiatives that are addressing these factors. Examples of such factors discussed in the portfolio analysis include fog and low ceiling (both in the ceiling and visibility service area) and terminal area winds.

Conclusion 5. Curtailment or delays in implementation of useful new products, services, and systems could jeopardize achievements in accident reduction that seem



Restricted visibility can hide other aircraft as well as dangerous terrain. © AOPA, all rights reserved.

within reach if we stay the course. Continued support is essential for these efforts, which are nearing the point of producing real returns and achieving a national safety priority.

Recommendation 5. Investment should be sustained for aviation weather projects and programs whose results are likely to further reduce the risks from weather hazards that continue to be cited in aviation accidents. All the partners whose joint efforts in the past have made possible the progress documented in this assessment must continue their commitments and strengthen their collaborations.

Sustaining R&D to Continue Improving Aviation Safety

Many of the projects included in the overview of current programs and initiatives are indirectly relevant to reducing the risks from multiple weather hazards because they provide general supporting capability. For example, dissemination systems or decision support and cockpit display infrastructure are needed to communicate turbulence information to pilots. In principle, these same systems should be communicating and processing information on all the other weather hazards the pilot is facing, along with other aviation safety information. (The Safe Flight 21 program described above illustrates this integrated approach.) In addition, many aviation weather projects either have already contributed to reducing accident rates or will sustain existing achievements as implementation expands throughout the National Airspace System. Terminal and en route icing forecast products, as well as de-icing decision support systems, are among the examples in this category. Other projects address hazards that have not yet shown up in NTSB accident statistics. For example, international flights by U.S. aircraft need technology to detect and forecast volcanic ash plumes aloft, even though volcanic ash plumes have not (yet) been cited as a factor in the NTSB reports, which cover only the National Airspace System.

To illustrate how projects and initiatives in each area complement and leverage one another, Section 4 includes

Technology exists to display current weather information graphically to the pilot en route. The challenge is to make the information available to every aircraft throughout the National Airspace System. Photo courtesy FAA Capstone program.

highlights of representative programs from each of the five aviation weather product areas. New weather information products must be disseminated to end users who have been trained to use them correctly. As the information available increases, well-designed human-machine interfaces are necessary to convey the right information at the right time without distraction or confusion. Decision support capabilities and systems can integrate and interpret these multiple data items into a coherent "situational awareness" for the user.

Conclusion 6. The combined and complementary effects of implemented aviation weather R&D have produced substantial and continuing benefits for the entire aviation industry. Those benefits are passed on to passengers and consumers as increased safety during air travel and improved efficiency and access in the air transport of passengers and cargo. To continue the promising trends—and to overcome the remaining challenges—in reducing weather-related aviation risks identified in this assessment will require sustaining the R&D and implementation programs in progress.

Recommendation 6. The investments in national aviation weather programs and initiatives should be supported and promoted as an effective investment in the nation's future.