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Aviation Weather Programs—Portfolio Analysis

Portfolio Overview

As noted in the Introduction, the *National Aviation Weather Initiatives Final Baseline Tier 3/4 Report* (OFCM 2001) and the Aviation Weather User Forum (OFCM 2000) were initial efforts in a continuing OFCM analysis and status review of a national portfolio of aviation weather initiatives and programs. A new feature of the continuing Tier 3/4 analysis is a categorization of every program according to the type of benefit users would get from it; that is, the principal product or service. The five categories, which originated in the 2000 Aviation Weather User Forum, are:

- Weather product development (e.g., weather observation and/or forecast systems or system products)
- Weather product dissemination (e.g., systems or services that deliver weather products to end users)
- Education, training, and outreach (informing current and potential users about available weather products and how to use those products effectively)
- Cockpit displays (e.g., hardware/software systems to present current weather information to the in-flight pilot in real time)
- Decision support systems and capabilities (systems that help users interpret weather information using procedures, operational concepts, and regulations)

A series of tables (Tables 5 through 11) are presented at the end of this section to provide, at a summary level, an update and extension of the April 2001 Tier 3/4 release, drawing on the information being gathered for the next release. Tables 5 through 8 relate the programs led by federal agencies to the five program product categories listed above (table columns) and the eight aviation weather initiative service areas (table rows). Table 9 does the same for the aviation weather programs and projects led by universities, industry, or trade associations. The acronyms used in Tables 5 through 9 are explained in Table 10, which includes a brief description of the major results (benefit to users) of each program, as well as the lead and partnering entities. Tables 5 through 9 are color-coded to indicate whether the major product has already been implemented (implementation in FY 1997–2002), is in implementation now (FY 2003–04), or is expected to be implemented later in the ten-year program assessment period (FY 2005–07). This same information is indicated by a letter code in the “Status” column of Table 10. Many of the education and training programs listed in Table 10 have produced multiple courses or training modules. These are listed in Table 11. In the portfolio analysis below, program acronyms as given in Table 10 are highlighted in boldface.

Programs Relevant to the Hazard Analysis

This section looks at the aviation weather program portfolio in light of the five conclusions from the end of Section 3 on reducing the risk of weather-related aviation accidents. The intent is to draw out implications of those conclusions for managing the portfolio in the future.

Risk Reduction Success in General Aviation

Explaining the strong downward trends in Part 91 aviation accidents described in Sections 2 and 3 is at this point largely an exercise in conjecture. The downward trend is evident in all weather hazard categories, with the possible exception of Category E, temperature and lift hazards, and across all service areas. However, the

OFCM staff has accumulated enough anecdotal information and objective metrics to promote one conjecture to the status of a reasonable hypothesis for continued exploration. According to this hypothesis, the trends in accident reduction are largely due to an effective combination of multiple factors:

- Beginning in the 1990s and continuing through the present, the National Weather Service Modernization has produced a revolution in weather information products from Doppler weather radar, satellite imagery, improved numerical weather prediction models, and product dissemination systems. Many of these advances have improved the reliability and utility (e.g., finer scale observational and forecast data) of weather information products to aviation users—provided they get the information in useful form and within the time frames of their decision processes.
- Aviation-specific systems and products supported by the FAA, such as Terminal Doppler Weather Radar (**TDWR**), the Medium Intensity Airport Weather System (**MIAWS**), and the Weather System Processor (**WSP**) have increased the ability of air traffic controllers, traffic flow managers, and flight service station specialists to help the general aviation pilot avoid weather hazards during departure and landing.
- Information communication systems and weather product dissemination systems have made it easier for general aviation pilots to access the information available in improved weather products, particularly for preflight planning and in-flight decision making to avoid weather hazards. Public-private partnering and for-profit ventures have given general aviation pilots a range of affordable, practical, and reliable channels for information.
- Through education and training courses, large numbers of general aviation pilots have learned to use the information available to them to avoid hazardous weather conditions.

The last of these factors, education and training for the general aviation pilot, is the linchpin that ties together the first three factors, which provide the technology and service basis, into a success story.

The evidence for this explanation includes discussions OFCM staff members have had with representatives of the general aviation community, such as staff from the Aircraft Owners and Pilots Association (AOPA), supported by use statistics for education/training offerings and aviation weather dissemination systems. AOPA staff involved with aviation weather information for the general aviation community cited the following factors (AOPA 2003):

Pilot Education. Training programs (seminars and course offerings) have likely been a major contributing factor. Statistics are presented below on numbers of participants in some of the programs listed in Table 11.

Improved Availability and Quality of Aviation Weather–Related Information. Sources such as The Weather Channel®, which disseminates and interprets weather data and information from the National Oceanic and Atmospheric Administration (NOAA), and the Internet have significantly improved the quality, timeliness, and accuracy of weather information available to general aviation pilots. The Aviation Digital Data Service (**ADDS**), an Internet-based weather product dissemination service, has been widely used and accepted by the general aviation community. ADDS is funded by the FAA Aviation Weather Research Program (AWRP), with development and maintenance support from the National Center for Atmospheric Research (NCAR) and from NOAA's Forecast Systems Laboratory (FSL) and Aviation Weather Center (AWC). Data on ADDS user access are presented later in this section with the highlights of weather product dissemination programs.

The web page for ADDS, a product of interagency partnering, has become a favorite information source for general aviation pilots planning their next flight. ADDS provides current versions of weather maps and other products. Image courtesy NOAA/AWC.

More Use of Flight Services Briefings. Following the September 11, 2001, terrorist attacks using hijacked aircraft, aviation industry associations have been stressing to their members that pilots must pay attention to notices to airmen (NOTAMs) and receive a preflight briefing. As a result, general aviation pilots are calling flight information services more frequently. Along with NOTAMs for the pilot's route, the flight information services typically provide aviation routine weather reports (METARs), pilot reports (PIREPs), and other weather information.

Use of New Datalink Technologies for Weather Information in the Cockpit. The use of datalink technologies to obtain real-time graphical weather information (e.g., radar imagery) in the cockpit is just beginning to spread through the general aviation community as a whole. Business aircraft already appear to be frequent users of these technologies.

Increased Use of PIREPs. The SkySpotter Program, a collaborative training program of AOPA, the FAA, and NOAA, has been successful in training general aviation pilots in making and using PIREPs.

In *Aviation Weather Training*, the OFCM analyzed information about education and training programs received during data collection for the *Tier 3/4 Baseline Report*. The introduction to *Aviation Weather Training* reviewed the history of recommendations for improved aviation weather training since 1995 and the efforts that had been made in response to those recommendations (OFCM 2002). Data from course providers indicate strong pilot interest in these aviation weather offerings.

The Air Safety Foundation (ASF) and AOPA sponsor and approve courses for pilots as part of the Aviation Pilot Weather Education (APWE) program. The courses are developed and provided by contractors. From 1996 through the spring of 2003, the seminar-style course offerings had the following numbers of pilot attendees:

Aviation weather seminar	Attendees
Weather Strategies	25,880
Weather Tactics	19,605
Mountain Flying	1,556
Practical Weather Flying	289
“Never Again”	23,751
More “Never Again”	14,337
Operations at Towered Airports	19,622
SkySpotter	9,222

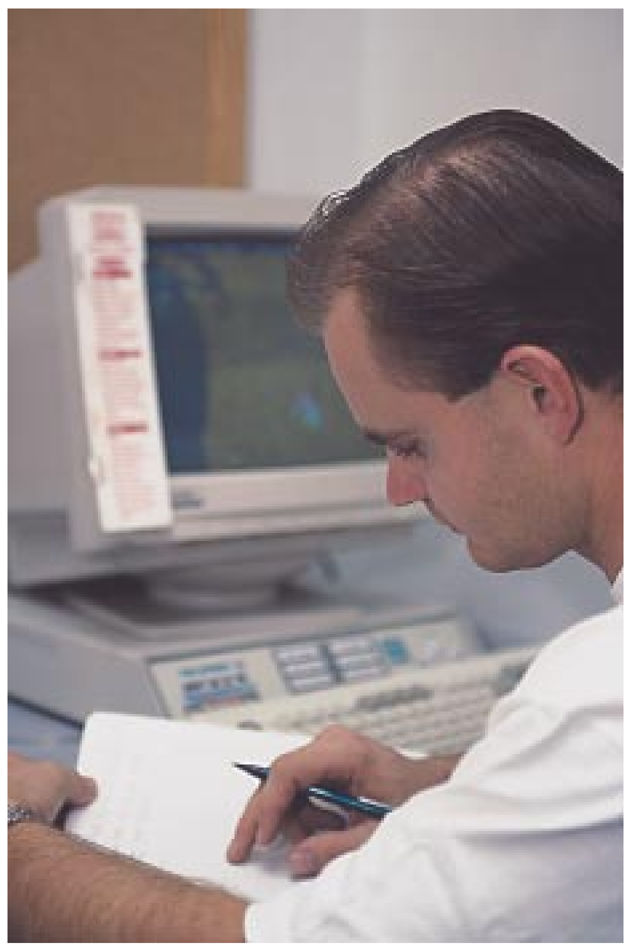
The annual numbers of attendees for the first seven of these courses (all but SkySpotter) were as follows:

Year	Attendees
1996	11,136
1997	12,287
1998	7,617
1999	27,494
2000	26,605
2001	7,052
2002	1,472
2003 (to date)	200

Beginning in 1999, ASF offered the seminars on Weather Strategies, Weather Tactics, “Never Again,” More “Never Again,” and Operations at Towered Airports as videos. The yearly distribution of these “seminars-in-a-box” is shown below:

Year	Sets distributed
1999	2,275
2000	2,025
2001	4,975
2002	6,050
2003 (to date)	3,275

In addition, in 2001–02, ASF sold the Weather Decision Making video to 41,758 pilots who had just received their instrument rating. Another 15,000 videos are likely to be mailed in 2003. The video stresses the importance of instrument flight rules (IFR) proficiency and working with the air traffic control (ATC) system to deal safely with convective storm hazards and other challenging weather. It addresses the limitation of ATC radar and discusses



Computer-aided instruction allows pilots to acquire and hone aviation weather skills using their home computers. © AOPA, all rights reserved.

how pilots can get the most value from preflight briefers, controllers, other pilots, Flight Watch, and other weather information sources (Sharitz 2003). ASF has been discussing collaboration aviation training programs with NOAA's National Weather Service (NWS).

As indicated in Table 11, the National Weather Association (NWA) currently offers two aviation weather courses on the Internet. As of spring 2003, the Thunderstorms and Flying course had been completed by 2,750 users of the NWA website. The Winter Weather and Flying course had been completed by 350 to 400 users.

Reducing Accidents for Part 135 Aviation

Part 135 aviation does not show the consistent downward trend since 1996 in the rate of all weather-related fatal accidents (Figures 3 and 4 in Section 2) that holds for general aviation. The Section 3 hazard category analysis shows that the problems are spread across hazards, and therefore across the aviation weather service areas (Table 2). An OFCM staff review of the Part 135 accidents in 1997 and 1998, as reported by the NTSB (NTSB 2002a, 2002b), found that the accidents occur across revenue service categories (scheduled versus nonscheduled, passenger and cargo) and across geographical regions. Anecdotes and opinions expressed by representatives from this aircraft regulatory category and by officials familiar with it suggest that multiple factors are involved.

Helicopters used for fighting wildfires are often Part 135 aircraft. Photo courtesy Dr. Timothy Brown, Desert Research Institute.

Diversity of Part 135 Operations and Services. Part 135 covers a broad range of niche applications, as well as small (less than ten passengers) scheduled air carriers and nonscheduled air taxi services (both passenger and cargo). Leased or chartered services provided by Part 135 aircraft, either fixed-wing or helicopter, include air taxi service, medical evacuation, and search and rescue. A variety of inherently dangerous aviation services, such as agricultural spraying, wildfire spotting, and emergency medical flights are included in the Part 135 mix. For some of these services, such as emergency medical flights or search and rescue, flying into or landing in hazardous weather conditions can be an essential part of the service provided.

Part 135 aircraft in Alaska often fly passengers and cargo, using natural waterways as runways. Photo courtesy Wings of Alaska Airlines, © Mike Mastin.

Resource Constraints on Decision Support Structure. Unlike the Part 121 carriers, many Part 135 operations are small businesses with limited decision support infrastructure for the pilot either during flight planning or en route.

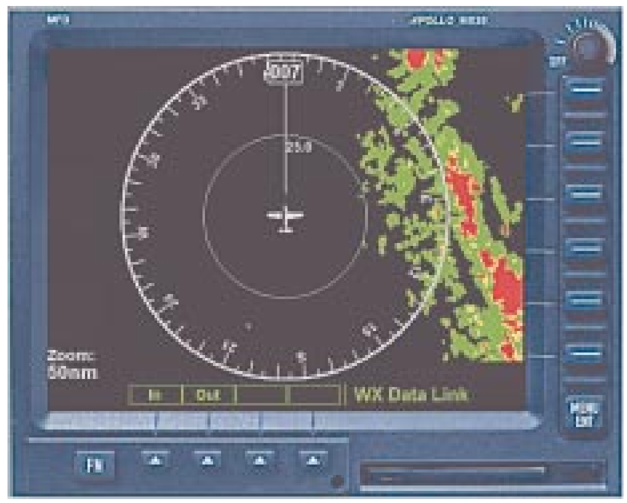
Resource Constraints on Upgrading Aircraft and Avionics. The small companies in this aircraft regulatory category often lack the financial resources to invest in new aviation weather technology, particularly when the up-front costs are substantial relative to the value of the aircraft. According to National Air Transportation Association (NATA) staff, more than 90 percent of the approximately 2,900 Part 135 operators have fewer than 25 employees and less than $5 million in annual revenue. More than 50 percent have five or fewer employees. Although 46 percent of the Part 135 fleet is turbine-powered, 60 percent of the fleet is more than 20 years old (Rosser 2003).

Reliance on Safety Infrastructure of Small Airports. According to NATA staff, adverse weather poses the highest risk to flight operations during the approach to the destination airport (or landing at a remote site, as in emergency rescue), rather than during the departure or en route phases of a flight. NATA has long advocated enhancing the weather services available to crews during the landing phase of flights, particularly at smaller general aviation airports and in rural areas. Ultimately, most small-aircraft Part 135 crews rely on government-sponsored resources for their flight weather information. However, according to NATA staff, long-promised equipment upgrades for some of these smaller destination airports, such as Automated Flight Service Station upgrades, often have not been implemented (Rosser 2003).

Differences from General Aviation Not in Revenue Service. Unlike most general aviation pilots, who fly at similar altitudes and also use smaller airports, Part 135 pilots and operators have strong economic incentives to meet prior flight commitments with respect to time and destination. Every Part 135 pilot undergoes mandatory initial and recurrent training, which is supervised and approved by the FAA and includes training and review on aviation weather topics. Although this training is in excess of that required for crews engaged in Part 91 operations, some of the Part 135 services (as noted above) call for flights through and landings during hazardous weather conditions.

With these broad characterizations in mind, the OFCM staff reviewed the aviation weather programs and projects to identify those in or nearing implementation that could make a difference to the accident experience of this aircraft category (as well as supporting the downward trends for the Part 91 and Part 121 categories). A key requirement is to bring together the advances in weather observation and forecast technology—which in principle are available to the entire aviation community—with the communications and information interpretation (decision support) technologies needed to deliver weather information to the Part 135 pilot. Further, real-world solutions must also be within the cost constraints of the business models within which these services operate.

The most promising initiative with potential for broad application to a range of weather hazards, within the constraints faced by a Part 135 pilot, is the weather information capability included in FAA's Safe Flight 21 program. Safe Flight 21 is a joint government-industry initiative to validate the capabilities of advanced communication, navigation, and surveillance technologies and related air traffic procedures. The key enabling technology on which Safe Flight 21 and its Alaskan Region demonstration program, **Capstone**, are based is Automatic Dependent Surveillance–Broadcast (ADS-B). ADS-B gives an aircraft with the requisite data uplink/downlink and cockpit display capabilities the same information about other aircraft in the vicinity as ATC now receives. For controllers, ADS-B provides a consolidated picture of the controlled airspace, especially aircraft operating in areas not covered by radar. ADS-B represents the technology implementation of the Free Flight concepts advocated by RTCA, Inc., and others in the aviation community, as those concepts have evolved over time (FAA 2003b, Scardina 2002, Lay 2003).



The Capstone demonstration program includes pilot training with simulated weather data on a multifunction display. A Part 135 pilot can use the display to show current weather radar data, air traffic, and terrain. Photo courtesy FAA Capstone program.

The direct relevance of this air traffic awareness system to aviation weather is that one of the two approved datalink technologies for ADS-B, the Universal Access Transceiver (UAT), will also provide an uplink for weather information via Flight Information Services–Broadcast (FIS-B). The weather data will be displayed on the same multifunction cockpit display used for the ADS-B display of traffic and for terrain data (Scardina 2002). A FIS-B capability, along with the ADS-B and Traffic Information Service–Broadcast (TIS-B), is being demonstrated in the Capstone program. For Capstone, the FAA provided up to 190 Part 135 aircraft in the region around Bethel, Alaska (the Yukon-Kuskokwim Delta Region) with an avionics package. The package consists of an IFR-certified global positioning system (GPS) receiver; the UAT, which provides ADS-B, FIS-B, and TIS-B data; a terrain database with capability for controlled-flight-into-terrain avoidance; and a multifunction color graphics cockpit display (CAASD 2003). The weather data being provided via FIS-B for

Capstone have included Next Generation Weather Radar (NEXRAD or WSR 88D), Terminal Aerodrome Forecasts (TAFs), and METARs (FAA 2003c). An FAA Capstone newsletter includes stories from Alaskan air taxi pilots indicating that these users are increasingly enthusiastic about the system, particularly its utility in instrument meteorological conditions (IMC) and the rapidly changing ceiling and visibility conditions of Alaska.[1]

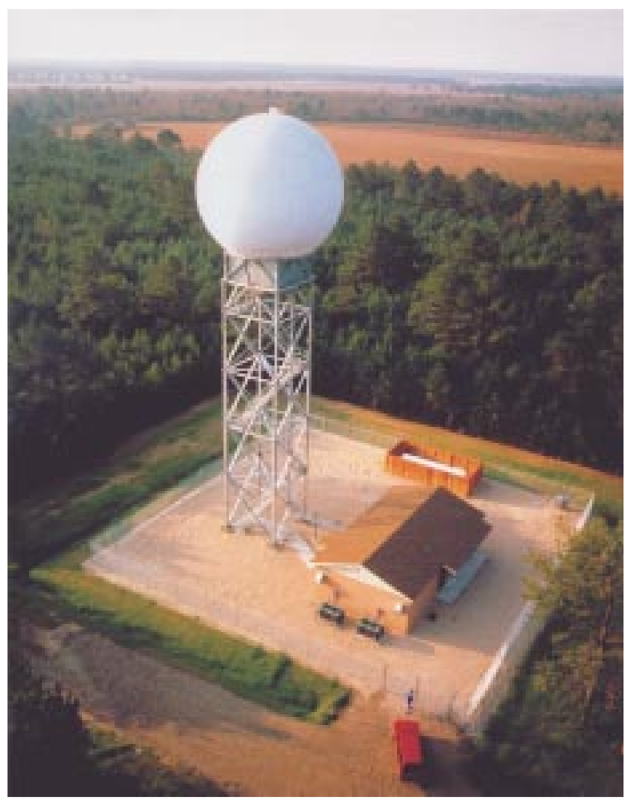
An interim deployment of the ADS-B technology on the U.S. East Coast was just beginning as of June 2003, with test and evaluation planned for 2004–05. The weather products that will be included in this deployment are still under evaluation. According to the FAA, when full deployment of ADS-B and FIS-B is achieved (2012 or later), coverage will be sufficient for Part 135 operations throughout the United States. The focus of Safe Flight 21 is on Part 91 and Part 135 aircraft. However, aircraft operators will need to install the UAT datalink technology (rather than the second ADS-B technology, the 1090 MHz Extended Squitter) to receive the FIS-B uplink data (Scardina 2002, FAA 2003c).

In summary, the FIS-B capability in Safe Flight 21 appears to offer a long-term solution for getting current weather information, along with terrain visualization, to the Part 135 pilot en route. This system will also benefit the Part 91 pilot, helping to extend the downward accident trends, hopefully to near-zero rates. Because much of the ground infrastructure for communications and information processing will be FAA or NOAA supported, and the weather information is packaged with the ADS-B technology, the cost of equipping aircraft is likely to be acceptable to the Part 135 industry and to most general aviation pilots/operators. (The avionics package provided for Capstone cost $15,000–$20,000 per aircraft in 2000 [Olmos and Mittelman 2000].) Once the data uplink is in place, additional information on weather hazards can be incorporated. Unfortunately, the current deployment schedule does not give coverage across most of the National Airspace System (NAS) until the 2007–12 time frame, which will not help in meeting the national aviation weather accident reduction goals by 2007.

Because of the diversity of aircraft operations covered by Part 135, particularly the range of aviation services offered, the hazard analysis for this assessment should be viewed as only highlighting a problem area that needs more detailed analysis. A case analysis of weather-related Part 135 accidents, with attention to grouping of accidents into relevantly similar flight/service conditions, would help shed light on the factors underlying the overall trends noted in this report.

Reducing Risk from Turbulence and Convection Hazards

The major air carriers (Part 121 aviation) have reduced fatal weather-related accidents to a rare event (see Table 3). Consequently, this mid-course assessment has turned to the record of weather factors cited in all accidents, fatal or not, to look for trends indicating which hazards remain a threat (see Table 4). As Table 4 and Figure 13 show, one hazard category, turbulence and convection hazards, accounts for substantially more than half of the citations in every year since 1995. If the trends of 1995 through 2001 continue, this single category would, by 2007, account for nearly all weather citations, every year, in Part 121 aviation accidents. These weather factors fall in three of the aviation weather service areas (see Table



TDWR is just one of the FAA-supported systems already implemented that can reduce the risks from turbulence and convection hazards. Upgrading these systems and extending coverage to more airports will reduce the risk of fatal accidents. Photo courtesy FAA.

[1]Issues of the newsletter are available at the FAA Alaskan Region website for Capstone: www.alaska.faa.gov/capstone.

2): convective hazards, terminal winds and temperatures, and turbulence.

Part 121 is not alone in facing turbulence and convection hazards. Although both the Part 91 and Part 135 data show *fatal* accidents for this hazard category trending to zero, the downward trends for *all* weather-related accidents do not show the desired 80 percent reduction by 2007 (Figures 10 and 17). Therefore, although progress in addressing turbulence has been substantial, a closer look is needed at what more can be expected from programs in progress and what additional efforts may be appropriate. The following review draws on programs and projects from all three turbulence-related service areas.

Flying in clouds and mountainous terrain, a pilot must be ready for turbulence and convection hazards, as well as sudden changes in visibility and ceiling. Photo courtesy Wings of Alaska Airlines, © Fred Hirschmann.

A newly operational weather product that should help Part 121 aviation avoid in-flight turbulence and convection hazards is the Graphical Turbulence Guidance (**GTG**) from the FAA's AWRP. This guidance for aviation weather forecasters is based in part on a recently developed turbulence forecast algorithm. The current operational algorithm gives numerical weather prediction models the capability to predict upper-level clear air turbulence above 20,000 feet (Flight Level 200). This makes the product primarily useful for Part 121 aviation. To produce a GTG product, the turbulence forecast is combined with turbulence observations, including PIREPs. Improvements to the turbulence forecast algorithm, expected during the next several years, will enable predictions for other sources of turbulence, such as terrain-induced and convective turbulence. AWRP plans to include guidance for turbulence down to 10,000 feet within the next year. These improvements could make the GTG more useful in forecasting turbulence relevant to the Part 91 and Part 135 aircraft categories.

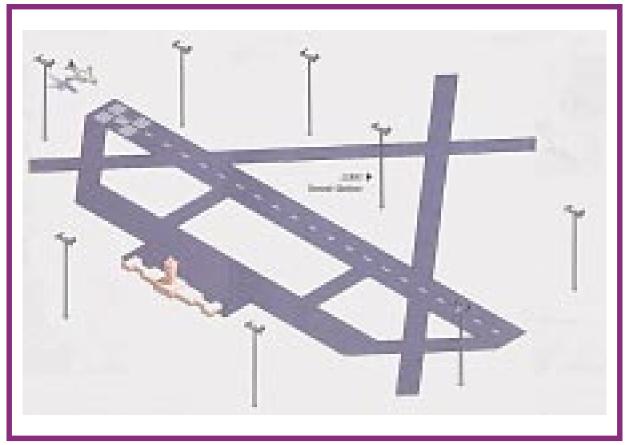
The AWRP is also developing the In-Situ Turbulence Algorithm (**ITA**), a promising new source of turbulence observational data, which will eventually be incorporated into GTG products. The ITA software package will reside in the Aircraft Condition Monitoring System (ACMS) of commercial air carriers. It converts high-rate vertical velocities and accelerations into an index of turbulence called the "eddy dissipation rate" (EDR), which is included in the ACMS real-time data downlink from the aircraft. The AWRP is continuing to develop and test the ITA, with the cooperation of several major air carriers. The International Civil Aviation Organization has approved the EDR approach used in the ITA as an international standard. In addition to improving the data ingest to turbulence forecast models, the ITA's real-time, objective, and quantitative reports will be valuable in verifying forecasts and validating models—an essential tool for continuing to improve forecast skill. Given the success of the approach, the capability to incorporate it into an existing data stream (the ACMS), and the potential value of the data for reducing risks from in-flight turbulence, the ITA could provide substantial benefits and should be continued.

Another approach for warning aircraft is to detect turbulence ahead, using on-board sensor systems. NASA is currently implementing a system that uses an aircraft's on-board weather radar to detect clear-air turbulence (**RADAR**). It is also working cooperatively with industry on a Light Detection and Ranging (**LIDAR**) sensor system to detect clear air turbulence. The LIDAR approach is a longer-term technology development effort than the radar approach.

The Turbulence Plot System (**TPS**) provides messages on turbulence and other weather factors to the cockpit for in-flight tactical decisions. This industry-developed system (developed by Northwest Airlines) uses aviation meteorologists to gather information from many sources and produce reports of hazardous weather conditions, for distribution to dispatchers and pilots. The system now covers eight weather hazards: clear air turbulence, mountain wave turbulence, thunderstorm activity, low altitude frontal wind shear, low altitude convective wind shear, volcanic ash, icing, and ozone. Text-formatted messages are transmitted in a standard format called the Turbulence Plot Message. The TPS incorporates detailed procedures for hazard avoidance and training modules for pilots, dispatchers, and meteorologists. ARINC has developed a system to display the Turbulence Plot Message graphically and is making it available to other airlines via a redistribution agreement with Northwest Airlines. This is an example of leveraging the product of an industry partner to achieve substantial results of value for the Part 121 aircraft category. At some point, an independent test and evaluation of TPS may be useful for encouraging its adoption or improving it for more widespread use.

Several weather factors in the turbulence and convection hazard category are relevant to terminal environments during departure and landing. These factors come under the service areas for convective hazards or terminal winds and temperatures.

Fortunately, there are a number of programs and projects that are in implementation now or will be ready for implementation in the near term and that can help forecast, detect, or warn of these hazards. The FAA's **WSP** (a modification for terminal surveillance radar), **MIAWS**, **TDWR**, and Low Level Windshear Alert System (**LLWAS**) are among the already implemented systems that provide direct observation of these near-terminal weather hazards. Within three to five years, the FAA plans to complete implementation of these systems, which were included in a national aviation weather initiative to expand the number of airports at which microburst and low-level wind shear services are available (OFCM 2001, pp. 3–6; FAA 2003a, p. 8). In addition, the Terminal Convective Weather Forecast (**TCWF**), Wind Gust Potential Product (**WGPP**), and Weather Research and Forecasting (**WRF**) model are FAA-supported products or forecast development programs that will aid in forecasting these hazards. The NOAA-supported Dallas-Fort Worth Collaborative



The FAA-developed Low Level Windshear Alert System uses multiple wind sensors arrayed around the terminal area to detect wind shear and alert aircraft and controllers. Image courtesy FAA.

Aviation Forecast Study (**DCAFS**) will also help. Systems to disseminate observational and forecast products to air traffic control and pilots include the Flight Information Services Data Link (**FISDL**) for general aviation aircraft, the FAA's Operational and Supportability Implementation System (**OASIS**) for workstations at Automated Flight Service Stations, and NASA's Weather Information Communications (**WINCOMM**) datalink technologies for graphical cockpit display. Among the industry-led efforts are Automatic Delivery of Wind Shear Alerts (**ADWSA**) and the TPS (described above). The NASA WINCOMM project is developing satellite-communicated delivery of wide-band graphical products to the cockpit, including terminal hazard alerts, through cooperative research agreements (CRAs) with industry. One such effort involves the test and evaluation of a worldwide weather datalink capability using broadcast Satellite Digital Audio Radio Service (**S-DARS**).

Continued support for these R&D and implementation programs in progress is important to reap the benefits they offer for reducing the risks from turbulence and convection hazards. For many of the operational systems and products that are already available, as well as for those soon to be available, implementation at smaller or less-busy airports is constrained by budgets. In an environment of budget cutbacks at federal agencies and economic difficulties for airlines and the aviation industry generally, there are pressures to curtail the investments in technology needed to reduce fatal accidents involving terminal area turbulence and convection hazards. The continuing 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.

Reducing Risk from High Density Altitude

High density altitude is a weather factor in the terminal winds and temperatures service area (see Table 3). As the text box below explains, density altitude is a criterion for the combined effects on aircraft flight performance of temperature, altitude, and humidity. Additional factors are the particular airframe, engine, fuel-air composition feeding the engine, and weight and balance of the loaded aircraft. If a sufficiently knowledgeable pilot has current, correct data on all these factors and has adequate time to make the necessary computations and weigh all the interacting, relevant factors, the pilot should be able to avoid an accident due to high density altitude. The trends in the frequency at which this factor is cited for general aviation, and even Part 135, accidents indicate that pilots continue (not surprisingly) to have problems with density altitude (see Table 3 and Figures 11 and 18). The problem can, and should, be attacked on three fronts.

1. Accurate data are needed on the conditions (temperature and humidity) for the location and time at which a pilot will be in a situation where density altitude matters most (typically takeoff and landing, but also during high power-required conditions in flight). For takeoff, this probably means current temperature and humidity on the runway and in the flight path during ascent. For landing, it may mean an accurate forecast of those weather parameters when the plane is scheduled to be approaching, available during flight planning, as well as current observations just prior to approach for landing.
2. The multiple factors involved in determining density altitude (including the effects of humidity on engine performance) and assessing how it will affect a particular aircraft's airframe, engine, and loading constitute just the kind of problem that an information-technology-based decision support capability can solve for the pilot.
3. Even with a good decision support tool, the pilot needs to know how to respond to the advice (or output) offered by the tool. Education about density altitude and training in how to get the necessary input data and derive the right answer will be essential to success, even when much better decision support tools are on the market.

Density Altitude—Hot, High, and Humid Air

Density altitude is a flight performance factor, not a measure of altitude. Roughly, it measures the effects of air temperature, altitude (usually, the elevation of a takeoff or landing), and humidity on the performance of the aircraft. Aircraft manufacturers provide information on a general aviation aircraft's performance under standard atmospheric conditions corresponding to sea level and 59 °F. When the air is less dense than under these standard conditions, there is less air flowing over the camber of the wing. The aircraft experiences less lift at a given airspeed than at the standard conditions. Air that is warmer or at a higher altitude than the standard conditions is less dense. Density altitude is a measure of how much less dense the air is than it would be at standard conditions. In particular, higher temperatures at high elevations substantially increase the density altitude.

Density altitude effects are not confined to mountain areas. They also can be serious at lower elevations if temperatures are well above the standard 59 °F. In these conditions, the third factor in density altitude, humidity, magnifies the air-thinning effect of temperature. The amount of water vapor in the air affects the engine power rather than the aerodynamic efficiency of the aircraft. At 96 °F, the water vapor content of the air can be eight times greater than at 42 °F. Exactly how a higher humidity will affect engine performance (and thus the "altitude" the aircraft appears to be experiencing) depends on the particular engine and its fuel-air mixture (lean versus rich). The Koch chart often used to figure the effect of temperature on the density altitude at a given elevation does not explicitly include the humidity factor. The FAA recommends that pilots departing in humid, warm conditions add an additional 10 percent to their computed takeoff distance and anticipate a reduced climb rate.

As density altitude increases, takeoff distance, power available (in normally aspirated engines), and climb rate are adversely affected. Density altitude also increases the difference between indicated airspeed (it is lower) and true airspeed, an effect that can increase landing distances significantly beyond what a pilot is expecting. Weight and balance are also factors that pilots must take into account at high density altitudes, as stall conditions are affected.

SOURCES: FAA 2003d, FAA 2003e.

Sustaining Progress in Reducing Risks from Frequently Cited Weather Factors

The progress toward accident reduction goals for Part 91 aircraft in weather-related accidents has been substantial, but the ten-year goals have not yet been achieved. Among the factors that continue to cause fatal accidents each year are fog and low ceiling, which fall in the ceiling and visibility service area. Some of the programs for the ceiling and visibility service area that will address these weather factors are discussed below.

The terminal winds and temperatures service area comprises a number of factors that continue to be cited each year in multiple fatal accidents, including gusts and terminal area winds (tail wind, crosswind, or high winds). The programs discussed above for addressing turbulence and convection factors in the terminal area will also address these hazards.

The national initiative to address en route ceiling and visibility hazards through weather product development is led by the National Ceiling and Visibility (**NCV**) Product Development Team within the FAA's AWRP. At present, the NCV Product Development Team has two products in the testing stage: an analysis product and a forecast product. These products are scheduled to become experimental in FY 2005 at the AWC and operational in FY 2006–07. Key partners in the development efforts have included NCAR, the Naval Research Laboratory, Massachusetts Institute of Technology (MIT) Lincoln Laboratories, and NOAA's FSL.

The Terminal Ceiling and Visibility (**TCV**) Product Development Team of the AWRP has been working on the Marine Stratus Forecast System (**MSFS**), which produces near-term (0 to 6 hour) predictions of when marine stratus formations will lift. Another TCV product will provide ceiling and visibility forecasts for airports where IMC commonly result from large weather systems during the winter season in the Northeast.

NASA, which was a partner in the early work of the NCV Product Development Team, is now working in collaboration with the FAA on a related effort, the Advanced Satellite Aviation Products (**ASAP**). The Phase I product will make better use of current weather satellite data in aviation applications that include ceiling and visibility observations and forecasts. Phase II of ASAP, scheduled to begin in FY 2006, will focus on incorporating high-resolution (spatial and temporal) data on winds, atmospheric temperature, and moisture, which will become available from a geostationary operational environmental satellite (GOES) in the 2010–12 time frame. The improved resolution of water vapor and winds will enhance numerical weather prediction modeling, as well as improve dispersion forecasts of volcanic ash plumes.

A ceiling and visibility product produced from the current GOES is the NOAA National Environmental Satellite, Data, and Information Service (NESDIS) Low Cloud Product (**LCP**). The LCP, which helps forecasters establish areas of widespread low clouds, is scheduled for incorporation in the NWS Advanced Weather Interactive Processing System (**AWIPS**) early in FY 2004. As further refinements are made to the LCP, they will be incorporated into this AWIPS-distributed product for weather forecasters and aviation meteorologists.

An aircraft's instrument panel is crowded with information the crew must assimilate. Incorporating graphical weather information on multifunction displays can ease the information load. Photo courtesy FAA Capstone program.

Highlights of Past, Current, and Future Implementations

The preceding section discussed aviation weather programs and projects of direct relevance to the conclusions from the accident analysis. Other entries in Table 10 are indirectly relevant because they supply 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, as well as other aviation safety information. (The Safe Flight 21 program described above illustrates this integrated approach.)

In addition, many of the Table 10 projects either have contributed already to reducing accident rates, or they will sustain and improve the progress already made, as implementation begins or expands throughout the NAS. Terminal and en route icing forecast products, as well as de-icing decision support systems, are among the examples in this category. Other projects, such as systems to observe and forecast models to predict atmospheric transport of volcanic ash plumes, address known hazards that need to be avoided, even though they do not show up in the NTSB accident data during the period analyzed for this assessment.

The gist of the rationale for each project is represented in the user benefit column in Table 10. This section provides an overview of the breadth of activities under way by highlighting a few of the most important efforts in each of the five product/service categories (the main product column in Table 10). Programs were selected for discussion based on their likely impact on weather-related accident rates, their contribution to a safer and more efficient NAS, and the extent of partnering they involve, both among federal agencies and across public–private sector boundaries.

Weather Product Development

The Collaborative Convective Forecast Product (**CCFP**), which became operational in May 2000, illustrates successful partnering among the FAA, NOAA, and airline meteorologists. Convective activity has been the single most frequent source of weather-related delays and disruptions in the NAS. CCFP is reducing these disruptions by providing air traffic flow managers (e.g., airline dispatchers) and air traffic controllers with a more accurate forecast of convective weather (AWC 2003). Convective activity is also a major source of turbulence and convection hazards.

The forecasts produced are *collaborative* because an AWC forecaster develops a preliminary forecast, on which the Center Weather Service Units and airline meteorologists comment, based on their respective areas of responsibility. The AWC forecaster uses this input, received in real time via a restricted-access Internet chat room, to revise the final forecast product before posting it on the CCFP website at the published issue time. Beginning in July 2002, the frequency of CCFP issuance increased from a four-hour to a two-hour cycle. End users include the ATC System Command Center, airline dispatchers, airline area of concern/ATC coordinators, and traffic management units at airports (AWC 2003). CCFP forecasts are available to the general aviation community via **ADDS**.

To improve the CCFP over time, the convective forecasts are compared with actual weather conditions for accuracy. Statistical results are computed by the Real-Time Verification System, operated by NOAA's FSL and supported by the FAA's AWRP through its Quality Assessment Product Development Team. Thus, the value of CCFP to the NAS should increase over time.

The **WRF** model, mentioned above as an indirect contribution to dealing with turbulence hazards, is a multiyear development project being undertaken by a coalition of public-private partners. The principals include NOAA, through its National Centers for Environmental Prediction (NCEP), FSL, and National Severe Storms Laboratory; NCAR; the U.S. Air Force Weather Agency (AFWA); the National Science Foundation; the U.S. Navy; and the Center for Analysis and Prediction of Storms (CAPS) at the University of Oklahoma. The two major goals of this effort are (1) to develop an advanced mesoscale forecast and data assimilation system, and (2) to promote closer ties between research and operations. A basic WRF version, incorporating simple model physics, was released to the community for testing and evaluation in 2000. However, the operational impact of WRF for aviation weather is just beginning.

WRF is already being tested for many forecast applications. Testing for initial operational use at NCEP, AFWA, and FSL is under way, with implementation in operations scheduled for late 2004. For aviation weather, its principal benefits include a design that can accommodate horizontal grids of 1 to 10 km and improved forecast accuracy and efficiency across a broad range of scales. AFWA, for example, is using WRF for real-time applications at synoptic scales (e.g., the continental United States). Other applications are using WRF for regional and storm-level forecasting. Improved forecasts of weather-related variables that affect aviation will improve the safety and efficiency of NAS operations.

Volcanic ash plumes are a hazard for international flights by U.S. aircraft, as well as being a hazard within the NAS downwind from volcanic activity (e.g., Alaska and Hawaii). NOAA's Volcanic Ash Forecast Transport and Dispersion Model (**VAFTAD**) is already in use for forecasting ash dispersion. VAFTAD will soon be replaced by the Hybrid Single Particle Lagrangian Integrated Trajectories

(**HYSPLIT**) model for improved dispersion forecasting. The Volcanic Ash Product (**VAP**) and Volcanic Ash Graphic (**VAG**) are volcanic ash detection and ash advisory products NOAA is now implementing. The FAA's AWRP is working on a Volcanic Ash Warning (**VAW**) product to help aircraft avoid volcanic ash over the oceans. Volcanic ash detection and plume migration forecasting will be improved further when the Geosynchronous Imaging Fourier Transform Spectrometer (**GIFTS**) is incorporated in the next generation of geostationary weather satellites. These and other projects and initiatives to deal with the volcanic ash plume hazard to aviation will be topics for discussion at a summer 2004 symposium on volcanic ash and aviation safety.

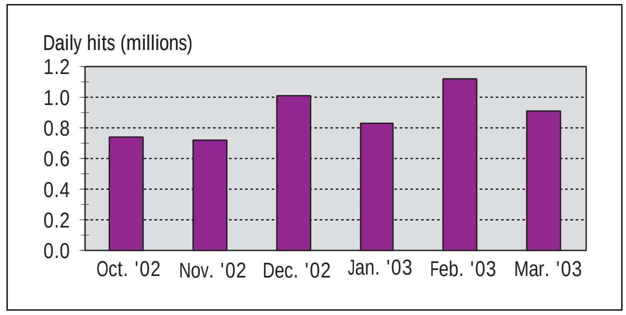
Weather Product Dissemination

Before products such as CCFP and the emerging applications of WRF can improve aviation safety, users must have access to them in a form relevant to their decision-making processes. As noted above, CCFP forecasts are available via the Internet for the strategic traffic management decisions made by air traffic controllers and traffic flow managers. Another Internet-based dissemination system, aimed at the entire aviation community and particularly useful to general aviation pilots, is **ADDS**, which was discussed above as one factor reducing the accident rates for general aviation. The products available at the ADDS website (adds.aviationweather.gov) include experimental weather products. As noted previously, representatives of general aviation pilots report that this community finds the ADDS site extremely useful—another sign that the education and training programs in aviation weather are reaching this important audience.

The first version of ADDS was turned on for Internet access in 1997, with a more user-friendly interface added in 1998. It won a Government Technology Leadership Award in 2000. A recent improvement is a flight path tool, which provides user-friendly graphics about turbulence, icing, thunderstorms, and other weather hazards for user-specified flight altitudes and flight paths. ADDS is already being accessed routinely by pilots. Figure 20 shows the average *daily* hits (user accesses to the website) each month from October 2002 through March 2003. Figure 21 shows which weather products available on ADDS were accessed most frequently during March 2003.

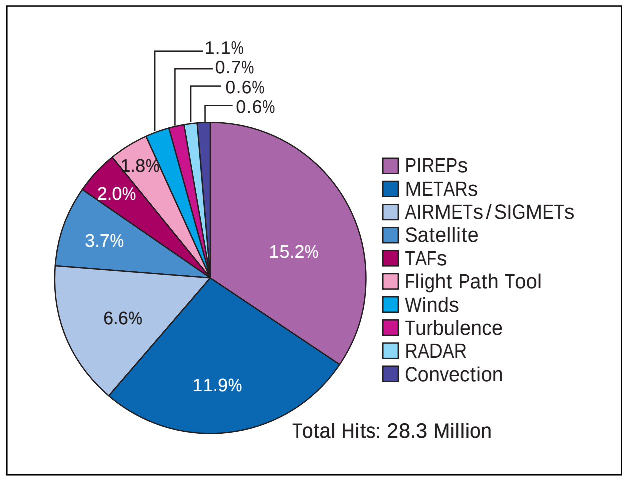
With the already planned improvements to ADDS and its potential to disseminate just-emerging weather products, ADDS will continue to improve the delivery of useful weather information to the aviation community through the remainder of the ten-year evaluation period.

Figure 20. Average daily hits on the ADDS website



Source: Mahoney 2003.

Figure 21. Top ten weather products on ADDS, by number of hits in March 2003



Source: Mahoney 2003.

Education, Training, and Outreach

As discussed above in relation to the trends of decreasing weather-related accidents for Part 91 aviation, pilot-oriented education and training courses in aviation weather appear to be a major contributing factor in the accident reduction rates observed since 1996. The earlier discussion included course statistics for two of the programs listed in Table 11, the APWE program by AOPA/ASF and the NWA's Internet-delivered courses. As Table 11 indicates, there are a number of other programs, most with multiple course offerings. Although OFCM staff have attempted to make the listing comprehensive, it probably does not capture all the offerings available.

The Cooperative Program for Operational Meteorology, Education and Training (**COMET**) offers a broad array of meteorology-related courses and programs. The course offerings listed for COMET in Table 11 represent just those with direct relevance to aviation weather. A difference between these courses and APWE or NWA offerings is that the COMET courses are typically oriented to aviation weather support specialists—e.g., aviation meteorologists and operational forecasters—rather than pilots.

The downward trend for general aviation in the rate of accidents involving icing hazards (Figure 9)—particularly when compared with an apparent upward trend for Part 135 (Figure 16)—suggests that general aviation pilots are more often taking appropriate precautions. These precautions may include staying away from reported or forecast icing conditions or escaping quickly if such conditions are encountered en route. NASA's Education and Training Program (**E&T**) has been a major contributor to the training and information sources available to the general aviation community. The videos listed in Table 11 for this NASA program are distributed at low cost through a pilot-oriented direct mail/Internet supplier.

Tables 10 and 11 list three new NOAA/NWS training initiatives: the Aviation Operations Course (**AOC**), Distance Learning Aviation Course (**DLAC**), and Pilot Training Initiative (**PTI**). The AOC, which is intended to train forecasters on the operational impacts on aviation of forecast products and preparation of TAFs, is being developed by the NWS Training Center and will probably be implemented within a year or two. The DLAC, developed by the NWS Training Center and COMET, combines distance learning (teletraining) and on-line exercises. The target audience is aviation weather focal points at Weather Forecast Offices. These focal points are expected to train other forecasters at their Weather Forecast Office. A DLAC Forecasting Fog and Stratus module is available now. A module on convective forecasting is planned for implementation within a year or two. The PTI is still in the planning stage, and there are encouraging signs that a collaboration between NWS and AOPA will be used for this initiative, which will focus on weather training for pilots.

In *Aviation Weather Training*, the Federal Coordinator for Meteorological Services and Supporting Research noted the need to "find and facilitate opportunities to leverage and collaborate on training among the federal agencies, industry, universities, and, where appropriate, the private sector" (OFCM 2002, pp. 2–18). That report identified opportunities to reduce training redundancies, improve access to needed training, and minimize training development costs. Further coordination is needed among the developers and providers of aviation training courses and materials listed in Table 11 to ensure that the entire aviation community has access to training that can reduce accidents, save lives, and improve the efficiency of NAS operations. Signs that the AOPA and NWS are working toward collaborating on pilot training courses are encouraging, but the players in the education, training, and outreach arena can go much further in leveraging efforts and collaborating to reach the target audiences with the greatest effectiveness and efficiency. The progress made in Part 91 accident reduction since 1996 shows that educating the general aviation community and providing them with access to the information for informed decision making is an effective approach.

Meetings and gatherings of the aviation community in which aviation weather is a program focus are often the first step in informing the community about the scope and value of course offerings and training materials, such as videos. These gatherings also can provide a venue where developers and vendors of course content and materials meet and develop collaborative approaches. Recent and upcoming outreach events are listed below.

- Experimental Aircraft Association (EAA) Airventure 2003; July 29–Aug. 4, 2003; Oshkosh, WI
- 72nd National Association of State Aviation Officials Annual Convention and Trade Show; Sept. 20–23, 2003; Charlotte, NC
- National Business Aviation Association Meeting; Oct. 7–9, 2003; Orlando, FL
- Friends/Partners in Aviation Weather Forum; Oct. 8, 2003, Orlando, FL
- NWA Annual Meeting; Oct. 18–23, 2003; Jacksonville, FL
- AOPA Expo 2003; Oct. 30–Nov. 1, 2003, Philadelphia, PA
- Second International Conference on Volcanic Ash and Aviation Safety; summer 2004

Following are past and recurring events with aviation weather interests.

- Various conferences conducted by American Meteorological Society committees such as the Aviation, Range, and Aerospace Meteorology Committee and the Broadcast Meteorology Committee
- Annual meetings of the Friends/Partners in Aviation Weather

- Annual meetings of the NWA
- Meetings of the Air Transport Association's Meteorology Committee
- Annual reviews of the FAA's Aviation Weather Research Program
- Annual reviews of NASA's Weather Accident Prevention project
- Meetings of RTCA, Inc., special committee on with-flight information services (SC 195)
- Annual AOPA expositions
- Annual Airventures, sponsored by EAA
- Various conferences and forums sponsored by the FAA, such as the In-Flight Icing/Ground De-Icing International Conference held in June 2003 in Chicago, IL
- Meetings of the American Institute of Aeronautics and Astronautics
- OFCM Aviation Weather User Forum, July 25–26, 2000, Bethesda, MD (see OFCM 2000 for proceedings)

Cockpit Displays

As the specificity and diversity of weather hazard information available in the cockpit increases, information overload of the pilot (or flight crew, on large aircraft) becomes an issue. Decision support capabilities and systems, which digest and interpret details into a decision-ready form, are part of the solution and are discussed below. Multifunction displays with well-designed graphics are another essential part of the solution. Particularly important is the integration of weather-related information with other flight information (flying parameters, terrain, ATC instructions) that require continual pilot/crew attention. For example, the multifunction display being used in the **Capstone** demonstrations in Alaska, as part of FAA's Safe Flight 21 program, provides real-time information on three-dimensional terrain, airspeed, groundspeed, air traffic (ADS-B), and GPS Wide Area Augmentation System location, as well as graphical and text weather information.

The instrument panel of a Part 135 aircraft participating in the Capstone demonstration program. Note the multifunction display showing weather radar data. Photo courtesy FAA Capstone program.

The private sector is responding to the potential market for weather-oriented cockpit displays. Cockpit display technology developed by NASA and Honeywell through a CRA is now being incorporated in Honeywell avionics products. For the general aviation market there are a number of weather datalink services, some with specialized cockpit display hardware.

Decision Support Systems and Capabilities

The FAA-developed Integrated Terminal Weather System (**ITWS**) processes and displays current and predictive weather information for the use of terminal air traffic management personnel. It is designed to support both safety and traffic planning objectives. For observational data, ITWS integrates data products from various FAA and NWS sensor systems, including TDWR, Airport Surveillance Radar–9 (ASR-9), NEXRAD (WSR 88D), **LLWAS**, and Automated Surface Observing System (**ASOS**). It also draws on the Meteorological Data Collection and Reporting System (**MDCRS**) and the NOAA Rapid Update Cycle (**RUC**) numerical weather prediction model. These sources are used for 20-minute nowcasts (conditions for the next 20 minutes), as well as for displaying current conditions. Products generated by ITWS include observed and forecast wind shear and microburst activity; information on storm cells, lightning, precipitation, terminal area winds aloft, and runway winds; and nowcasts of ceiling and visibility.

ITWS is an advisory tool for both strategic and tactical planning of the terminal airspace. The ITWS situation display, from which users work, includes an alert panel with six alert boxes, plus one or more weather windows for user-selected maps of current weather conditions and forecasts. The weather maps can cover from 5 to 200 nm out from the selected airport.

Prototypes of this FAA-funded decision support system have been in use at several airports since 1993. Feedback from these users has been a key factor in evolution of a useful and reliable system. A contract for the production system was awarded in January 1997. Thirty-seven systems will be installed by the end of FY 2003.

NASA's Aviation Safety Program, along with its industry partners, is making a significant investment in developing advanced cockpit displays that incorporate decision support capabilities. These synthetic vision systems (**SVS**) combine enhanced GPS location technology with high-resolution terrain databases to give pilots a three-dimensional graphical display of terrain around their flight path, regardless of the prevailing visibility conditions (NASA 2003). One such system, the Synthetic Vision/Highway in the Sky technology from Chelton Flight Systems, was recently approved by the FAA. A Chelton Flight Systems synthetic vision system is also part of the **Capstone** avionics suite and uses the same multifunction display as the NEXRAD (WSR 88D) maps and other weather information provided via the FIS-B communications datalink (Chelton Flight Systems 2003, CAASD 2003).

During the two decades from 1980 to 2000, much work was done on de-icing technology and on support tools to aid in deciding when and how best to de-ice aircraft. The FAA Winter Weather Product Development Team developed the Weather Support to De-Icing Decision Making (**WSDDM**) system to produce one-hour to two-hour nowcasts in real time of freezing or frozen precipitation in the terminal area, using Doppler weather radar, surface weather data, and snow gauges to determine precipitation type, temperature, wind speed and direction, and the liquid water equivalent of falling snow. The WSDDM technology was transferred in 1999 to a commercial developer and is now operational at the three major airports in the New York City area. The research on which WSDDM is based has also led to changes in how de-icing decisions are made by major airlines.

FISDL is a commercially available subscription service uplink to provide text and graphic flight services information, including both text and graphical weather products, to the cockpit. It is intended for use by the general aviation community.

The **Safe Flight 21** program, with its combination of ADS-B, TIS-B, and FIS-B communications links, a supporting ground infrastructure, and a multifunction cockpit display, illustrate the future direction of decision support systems for the general aviation and small-carrier pilot. Unfortunately, the full impact of Safe Flight 21 will not occur until well after the ten-year milestone for reducing aviation accidents related to weather.

Table 5. FAA-led aviation weather programs

Service area	Weather product development	Weather product dissemination	Education, training, and outreach	Decision support systems and capabilities
Ceiling and visibility	ADDS AWOS/ASOS RUC WRF NCV TCV	FISDL CDMNET WMSCR OASIS ADAS FBWTG	FAA Academy –ASOS –METAR/TAF –Basic Aviation Weather –Severe Weather –Integrated Terminal Weather System –Automated Weather Sensors System	MSFS RVR Capstone
Convective hazards	ADDS NCWF OCTH OACD OACN RUC WRF RCWF PA CA MRC AWOS/ASOS	FISDL CDMNET WMSCR OASIS ADAS FBWTG	FAA Academy –Basic Aviation Weather –Severe Weather –Weather System Processor –Integrated Terminal Weather System	WARP CIWS TDWR Capstone
En route winds and temperatures	ADDS MDCRS RUC WRF WVSS	FISDL WMSCR OASIS FBWTG	FAA Academy –Basic Aviation Weather –Integrated Terminal Weather System	WARP
Ground de-icing	AWOS/ASOS		FAA Academy –Ground De-Icing, Anti-Icing Operations –Basic Aviation Weather –Integrated Terminal Weather System	WSDDM
In-flight icing	ADDS CIP FIP WVSS RUC WRF SBID GRIDS PA	FISDL WMSCR OASIS FBWTG	FAA Academy –In-Flight Icing –Basic Aviation Weather –Integrated Terminal Weather System	WARP
Terminal winds and temperatures	ADDS TCWF MDCRS AWOS/ASOS RUC WRF JAWS CA	FISDL WMSCR OASIS ADAS FBWTG	FAA Academy –Low-Level Wind Shear Alert System –Basic Aviation Weather –Severe Weather –Integrated Terminal Weather System –Automated Weather Sensors System	ITWS MIAWS LLWAS-NE Capstone TDWR WSP
Turbulence	ITA GTG MDCRS OITFA RUC WRF NTDA ADDS	FISDL WMSCR OASIS FBWTG	FAA Academy –Wake Turbulence –Basic Aviation Weather –Severe Weather –Integrated Terminal Weather System	WARP Capstone
Volcanic ash	VAW	WMSCR FBWTG		

Legend: Already implemented (FY 1997–2002)
In implementation now (FY 2003–04)
Future implementation planned or scheduled for FY 2004–07 time frame

Table 6. NASA-led aviation weather programs

Service area	Weather product development	Weather product dissemination	Education, training, and outreach	Decision support systems and capabilities
Ceiling and visibility		WINCOMM		AHAS SVS AWIN
Convective hazards		WINCOMM		AHAS AWIN
En route winds and temperatures	TAMDAR ASAP GIFTS	WINCOMM		AHAS AWIN
Ground de-icing				
In-flight icing	TAMDAR ASAP	WINCOMM	PC-based Icing Simulator Education and Training –Icing for General Aviation Pilots –Tailplane Icing –Icing for Regional & Corporate Pilots –A Pilot's Guide to In-Flight Icing	AHAS AWIN
Terminal winds and temperatures		WINCOMM		AHAS AWIN
Turbulence	TAMDAR ASAP	WINCOMM		AHAS RADAR LIDAR AWIN ALDA
Volcanic ash	ASAP	WINCOMM		AHAS AWIN

Legend: Already implemented (FY 1997–2002)
In implementation now (FY 2003–04)
Future implementation planned or scheduled for FY 2004–07 time frame

Table 7. NOAA-led aviation weather programs

Service area	Weather product development	Education, training, and outreach	Decision support systems and capabilities
Ceiling and visibility	ASOS LCP WRF TAF GAF	NWS Training Center –Forecasting Low Level Clouds/Fog for Aviation Ops NWS Aviation Operations Course NWS Distance Learning Aviation Course NWS Pilot Training Initiative	AWIPS
Convective hazards	ASOS NLDN WRF TAF CCFP GAF	NWS Training Center –Severe Convection Forecasting and Warnings	AWIPS CCFP
En route winds and temperatures	WRF AWIPS	NWS Training Center –Low Level Wind Shear	AWIPS
Ground de-icing	ASOS		
In-flight icing	AIP WRF MMCR AWIPS	NWS Training Center –Forecasting Icing NWS Pilot Training Initiative	AWIPS
Terminal winds and temperatures	ASOS WGPP WRF TAF GAF	NWS Training Center –Low Level Wind Shear	AWIPS DCAFS
Turbulence	MWAVE WRF	NWS Training Center –Forecasting Turbulence –NWS Pilot Training Initiative	AWIPS
Volcanic ash	VAFTAD VAG VAP HYSPLIT		

Legend: Already implemented (FY 1997–2002)
In implementation now (FY 2003–04)
Future implementation planned or scheduled for FY 2004–07 time frame

Table 8. DOD-led aviation weather programs

Service area	Weather product development	Weather product dissemination	Education, training, and outreach	Decision support systems and capabilities
Ceiling and visibility	CDFS II N-TFS GTWAPS WRF C&V NAAPS ASOS NITES SMOOS (R) METMF MIDDS-T TAM	OPS II IMETS NFWB TEDS	Qualification Training Packages –Metwatch –Flight Weather Brief –Weather Elements	AMS TMOS RAWS
Convective hazards	N-TFS GTWAPS WRF NITES NSDS-E MRS ESID LPATS MIDDS-T TAM ASOS METMF OPUP	OPS II IMETS NFWB TEDS	Qualification Training Packages –Convection –Flight Weather Brief –WSR-88D PUP	AMS TMOS TWR SWR TEP
En route winds and temperatures	GTWAPS WRF NITES MIDDS-T METMF MRS	OPS II NFWB TEDS	Qualification Training Packages –Metwatch –Flight Weather Brief	MMS-P
Ground de-icing	ASOS		Qualification Training Packages –Weather Elements –Flight Weather Brief	AMS
In-flight icing	N-TFS WRF NITES NSDS-E METMF	OPS II IMETS NFWB TEDS	Qualification Training Packages –Weather Elements –Flight Weather Brief	IRP
Terminal winds and temperatures	N-TFS AOS GTWAPS WRF ASOS NITES SMOOS (R) MRS METMF	OPS II IMETS NFWB TEDS	Qualification Training Packages –Metwatch –Flight Weather Brief –Weather Elements –Convection	AMS TMOS RAWS TEP
Turbulence	N-TFS WRF MWFM NITES NSDS-E TAM METMF	OPS II IMETS NFWB TEDS	Qualification Training Packages –Turbulence –Flight Weather Brief –Convection –Weather Elements	
Volcanic ash	PUFF NAAPS	OPS II	Volcanic Ash Computer Based Training	

Legend: Already implemented (FY 1997–2002)
In implementation now (FY 2003–04)
Future implementation planned or scheduled for FY 2004–07 time frame

TABLE 9. Aviation weather programs led by universities, industry, and associations

Service area	Weather product development	Weather product dissemination	Education, training, and outreach	Cockpit Display	Decision support systems & capabilities
Ceiling and visibility	FFP	FISDL VDLM2	Aviation Pilot Weather Education –Weather Strategies –Weather Tactics –Mountain Flying –Practical Weather –"Never Again" –Operations at Towered Airports –SkySpotter Aviation Weather Hazards COMET EWINS NWA Internet Courses –Thunderstorms and Flying –Winter Weather and Flying		WebASD
Convective hazards	Hub-CAPS ATLAS AWIN CRA3 GLDI AWHCS	TPS AWIN CRA1 AWIN CRA2 S-DARS CRA SWIS-CRA WxITC FISDL VDLM2	Aviation Pilot Weather Education –Weather Strategies –Weather Tactics –Mountain Flying –Practical Weather –"Never Again" –Operations at Towered Airports –SkySpotter Aviation Weather Hazards COMET NWA Internet Courses –Thunderstorms and Flying	WINN	DA AWARE EWxR CRA WebASD
En route winds and temperatures	AWIN CRA3 AWHCS	TPS S-DARS CRA SWIS-CRA WxITC	Aviation Pilot Weather Education –Weather Strategies –Weather Tactics –Mountain Flying –Practical Weather –"Never Again" –SkySpotter Aviation Weather Hazards COMET NWA Internet Courses –Thunderstorms and Flying –Winter Weather and Flying		DA AWARE
Ground de-icing			NWA Internet Courses –Winter Weather and Flying		FDI

(continued)

TABLE 9. Aviation weather programs led by universities, industry, and associations (continued)

Service area	Weather product development	Weather product dissemination	Education, training, and outreach	Cockpit Display	Decision support systems & capabilities
In-flight icing	AWIN CRA3 AWHCS	TPS AWIN CRA AWIN CRA2 S-DARS CRA SWIS-CRA WxITC FISDL	Aviation Pilot Weather Education –Weather Strategies –Weather Tactics –Mountain Flying –Practical Weather –"Never Again" –SkySpotter Aviation Weather Hazards COMET NWA Internet Courses –Thunderstorms and Flying –Winter Weather and Flying	WINN	DA AWARE WebASD
Terminal winds and temperatures	Hub-CAPS	TPS FISDL ADWSA	Aviation Pilot Weather Education –Weather Strategies –Weather Tactics –Mountain Flying –Practical Weather –"Never Again" –Operations at Towered Airports –SkySpotter Aviation Weather Hazards COMET EWINS NWA Internet Courses –Thunderstorms and Flying –Winter Weather and Flying		
Turbulence	AWIN CRA3 AWHCS	TPS AWIN CRA1 AWIN CRA2 S-DARS CRA SWIS-CRA WxITC FISDL VDLM2	Aviation Pilot Weather Education –Weather Strategies –Weather Tactics –Mountain Flying –Practical Weather –"Never Again" –Operations at Towered Airports –SkySpotter Aviation Weather Hazards COMET NWA Internet Courses –Thunderstorms and Flying –Winter Weather and Flying	WINN	LIDAR DA AWARE EWxR WebASD
Volcanic ash		TPS	Volcanic Ash Avoidance		

LEGEND: Already implemented (FY 1997–2002)
In implementation now (FY 2003–04)
Future implementation planned or scheduled for FY 2004–07 time frame

TABLE 10. Aviation weather programs and projects

Acronym	Name	Main product[a]	Lead entity[b]	Lead office[b]	Partners	Status[c]	User benefit
ADAS	AWOS Data Acquisition System	Dissemination	FAA	AUA 400		I	Collection of surface observations from multiple sites
ADDS	Aviation Digital Data Service	Development	FAA	AWRP	NOAA, NCAR	N	Provide aviation weather products via the Internet; operational fall 2003
ADWSA	Automatic Delivery of Wind Shear Alerts	Dissemination	Industry	Northwest Airlines	FAA	I	Provide wind shear alerts to the cockpit
AHAS	Airborne Hazard Awareness System	Decision support	NASA	WxAP		F	Improve pilot's situational awareness
AIP	Aircraft Icing Product	Development	NOAA	NESDIS		N	Depict areas of icing potential for hazard avoidance
ALDA	Airborne LIDAR Detection Algorithm	Decision support	NASA	AvSP	FAA	F	Improve in-flight turbulence detection
AMS	Automated Meteorological System	Decision support	DOD	Air Force		N	Automated observations
AOC	Aviation Operations Course	Ed/train/outreach	NOAA	NWS		N	Train forecasters to provide better operational aviation forecasts
AOS	Automated Observing System	Development	DOD	Air Force		N	Collect data from multiple locations
APWE	Aviation Pilot Weather Education	Ed/train/outreach	Association	AOPA/ASF		I	Provide training materials for general aviation pilots (courses listed in Table 11)
ASAP	Advanced Satellite Aviation Products	Development	NASA	WxAP	FAA	N/F	Incorporate satellite data in aviation weather products
ASOS	Automated Surface Observing System Upgrades	Development	NOAA	NWS	FAA, DOD	N	Incorporate ice-free wind sensor in existing ASOS; other upgrades
ATLAS	Aircraft Total Lightning Advisory System	Development	Industry	Airborne Research	Rockwell-Collins Corp.	F	Detect and map total lightning
AWARE	Aviation Weather Awareness and Reporting Enhancement	Decision support DOD	Industry	Rockwell	NASA, FAA, NOAA,	C	Improve pilot's situational awareness; capability to be incorporated in AHAS decision support system (NASA)
AWH	Aviation Weather Hazards	Ed/train/outreach	University	U. of Kansas		I	Training on weather hazards for pilots (courses listed in Table 11)
AWHCS	Aviation Weather Hazard Characterization System	Development	University	U. of Oklahoma/ CAPS	NCAR, FSL, MIT/ Lincoln Labs	N	Create a 3-dimensional database of atmospheric variables
AWIN	Aviation Weather Information	Decision support	NASA	WxAP	Industry	N/F	Optimize human factors in display of weather information
AWIN CRA1	Aviation Weather Information (Datalink)	Dissemination	Industry	Honeywell	NASA	C	Datalink graphical weather information to general aviation aircraft; incorporation in commercial products at lead entity's discretion
AWIN CRA2	Aviation Weather Information (Datalink)	Dissemination	Industry	ARNAV	NASA	C	VHF datalink graphical weather information to general aviation aircraft; incorporation in commercial products at lead entity's discretion
AWIN CRA3	Aviation Weather Information	Development	Industry	Honeywell	NASA	C	Optimize route selection for dispatchers; incorporation in commercial products at lead entity's discretion

(continued)

Table 10. Aviation weather programs and projects (continued)

Acronym	Name	Main product[a]	Lead entity[b]	Lead office[b]	Partners	Status[c]	User benefit
AWIPS	Advanced Weather Interactive Processing System	Decision support	NOAA	NWS		I	Improved product generation, dissemination, and forecaster decision aid
C&V	Ceiling and Visibility	Development	DOD	Navy		N	Produce ceiling and visibility forecasts
CA	Circulation Algorithm	Development	FAA	AWRP		F	Detect storm circulations hazardous to aviation
Capstone	Alaskan Region Safe Flight 21	Decision support	FAA	AND-1	Air carriers in 2 Alaskan regions	I/N	Reduce accidents by providing traffic, terrain, and weather information to the cockpit via datalink technology
CCFP	Collaborative Convective Forecast Product	Decision support	NOAA	NWS	FAA, airline industry	I	Better forecasts of convective weather for traffic product management within NAS
CDFS II	Cloud Depiction and Forecast System	Development	DOD	Air Force		N	Produce cloud cover forecasts
CDMNET	Collaborative Decision Making Net	Dissemination	FAA	AUA		I	Dissemination of weather information to airline operation centers
CIP	Current Icing Potential	Development	FAA	AWRP		I	Depict areas of icing for in-flight avoidance
CIWS	Corridor Integrated Weather System	Decision support	FAA	AWRP		N	Regional convective nowcasts and forecasts for traffic management
COMET	Cooperative Program for Operational Meteorology, Education and Training	Ed/train/outreach	University	UCAR-NCAR	NOAA, AFWA, NMOC, NESDIS, MSC, NPOESS	I	Training modules for providers of aviation weather information (courses listed in Table 11)
DA	Divert Alerts	Decision support	Industry		Sonalysts, Inc.; United Airlines	I	Aid flight dispatch with diverted aircraft
DCAFS	Dallas-Fort Worth Collaborative Aviation Forecast Study	Decision support	NOAA	NWS		I	Improved TAFs for traffic management decision making
DLAC	Distance Learning Aviation Course	Ed/train/outreach	NOAA	NWS		N/F	Train providers on aviation weather hazards (courses listed in Table 11)
E&T Program	Education and Training	Ed/train/outreach	NASA	GRC		I	Provide pilot education on in-flight icing (courses listed in Table 11)
ESID	Electrical Storm Identification Device	Development	DOD	Navy		I	Lightning detection
EWINS	Enhanced Weather Information System Training	Ed/train/outreach	Industry	Northwest Airlines		I	Qualify meteorologists to write TAFs
EWxR	Enhanced Weather Radar	Decision support	Industry	Rockwell	NASA, FAA, NOAA, DOD	C	Extend range of airborne radar; capability to be incorporated in AHAS
FAA Acad.	FAA Academy Training	Ed/train/outreach	FAA			I	Courses listed in Table 11
FBWTG	FAA Bulk Weather Telecommunications Gateway	Dissemination	FAA			I	Dissemination of weather information to multiple users
FDI	Forecasting for De-Icing	Decision support	Industry	Northwest Airlines		I	Support de-icing decision making

(continued)

Table 10. Aviation weather programs and projects (continued)

Acronym	Name	Main product[a]	Lead entity[b]	Lead office[b]	Partners	Status[c]	User benefit
FFP	Fog Forecasting Process	Development	Industry	UPS		I	Forecasting process for radiation fog
FIP	Forecast Icing Potential	Development	FAA	AWRP		N	Forecast areas of icing for in-flight avoidance
FISDL	Flight Information Services Data Link	Dissemination	FAA	AUA 460	Industry	I	Provide weather information to the cockpit of general aviation aircraft
GAF	Graphical Area Forecast	Development	NOAA	NWS		N	Graphical depiction of weather information for easier user interpretation
GIFTS	Geosynchronous Imaging Fourier Transform Spectrometer	Development	NASA	ESE	NOAA	F	High-resolution atmospheric soundings
GLDI	Global Lightning Data Integration	Development	Industry	Sonalysts		N	Integrate global lightning data with other data sets over remote areas
GRIDS	Ground-Based Remote Icing Detection System	Development	FAA	AWRP		F	Improve ground-based detection of in-flight icing
GTG	Graphical Turbulence Guidance	Development	FAA	AWRP	NOAA	N	Improve short-term turbulence forecasts above Flight Level 200
GTWAPS	Global Theater Weather Analysis and Prediction System	Development	DOD	Air Force		I	Produce visualization products
GWIS	Global Weather Information System	Decision support	FAA	AUA-400		F	Replacement for WARP
Hub-CAPS	Center for Analysis and Prediction of Storms	Development	Industry	American Airlines	U. of Oklahoma / CAPS	I	Storm-scale forecasts supporting terminal operations
HYSPLIT	Hybrid Single Particle Lagrangian Integrated Trajectories	Development	NOAA	OAR / ARL		N	Improved volcanic ash dispersion forecasts for hazard avoidance
IHAS	Integrated Hazard Avoidance System	Decision support	Industry	Honeywell Bendix / King		I	Provide graphical information to the cockpit for decision support
IMETS	Integrated Meteorological System	Dissemination	DOD	Army		I	Dissemination of weather information
IP	Internet Protocol	Dissemination	FAA	ARS	NWS	I	Certify Internet weather providers
IRP	Icing Research Program	Decision support	DOD	Army	ERDC, CRREL, NASA, FAA, NCAR, NOAA	F	Detect in-flight icing
ITA	In-Situ Turbulence Algorithm	Development	FAA	AWRP		N	Measure and objectively report turbulence
ITWS	Integrated Terminal Weather System	Decision support	FAA	AUA 400		I	Ingrate terminal weather information from multiple sensors
JAWS	Juneau Airport Wind System	Development	FAA	AUA 400		N	Detect wind hazards at Juneau, Alaska, airport
LCP	Low Cloud Product	Development	NOAA	NESDIS		N	Safer operations in low clouds and reduced visibility conditions
LIDAR	Light Detection and Ranging	Decision support	NASA	WxAP	Industry	F	Early onboard detection of turbulence
LLWAS-NE	Low Level Windshear Alert System – Network Expansion	Decision support	FAA	ATB 420		I	Detect wind-shear at airports

(continued)

Table 10. Aviation weather programs and projects (continued)

Acronym	Name	Main product[a]	Lead entity[b]	Lead office[b]	Partners	Status[c]	User benefit
LPATS	Lightning Position and Tracking System	Development	DOD	Navy		I	Lightning detection
MDCRS	Meteorological Data Collection and Reporting System	Development	FAA	AWRP	NWS	I	Observation input to numerical model forecasts
METMF (R)	Marine Corps Meteorological Mobile Facility Replacement	Development	DOD	Navy		N	Mobile facility for METOC support
MIAWS	Medium Intensity Airport Weather System	Decision support	FAA	ATB 420		I	Provide integrated weather information at smaller airports
MIDDS-T	Meteorological Integrated Data Display System – Tactical	Development	DOD	Navy		I	Produce full range of forecast products for tactical use
MMCR	Millimeter Cloud Radar	Development	NOAA	NWS		F	Detect and avoid areas of supercooled liquid droplets
MMS-P	Meteorological Measuring Set – Profiler	Decision support	DOD	Army		F	Provide profiles of winds and temperature
MRC	Multi-Radar Composites	Development	FAA	AWRP		F	Integrate multiple radars and algorithms
MRS	Mini Rawinsonde System	Development	DOD	Navy		I	Mobile upper air soundings
MSFS	Marine Stratus Forecast System	Decision support	FAA	AWRP		N	Maximize arrivals at airports affected by marine stratus
MWAVE	Mountain Wave	Development	NOAA	NWS		N	Reduce injuries by avoiding areas of terrain-induced turbulence
MWFM	Mountain Wave Forecast Model	Development	DOD	Navy		F	Produce small-scale turbulence forecasts
NAAPS	Navy Aerosol Analysis and Prediction System	Development	DOD	Navy		F	Produce visibility forecasts supporting tactical operations
NCV	National Ceiling and Visibility	Development	FAA	AWRP	Navy, NOAA, NCAR, MIT/Lincoln Labs	N	Improve en route ceiling forecasts for general aviation
NCWF	National Convective Weather Forecast	Development	FAA	AWRP	NCAR, NOAA	I	Improve convective SIGMET forecasts
NFWB	Navy Flight Weather Briefer	Dissemination	DOD	Navy		I	Provide Internet-based flight weather briefs
NITES	Naval Integrated Environmental Subsystem	Development	DOD	Navy		I	Forecast toolkit and data distribution
NLDN	National Lightning Detection Network	Development	NOAA	NWS	FAA, DOD	N	Improve detection and forecasting of convection
NSDS-E	Naval Satellite Display System – Enhanced	Development	DOD	Navy		I	Receive and process satellite data
NTDA	NEXRAD Turbulence Detection Algorithm	Development	FAA	AWRP		N	Ground-based detection of turbulence
NTFS	New Tactical Forecast System	Development	DOD	Air Force		I	Produce weather products supporting aviation
NWA	National Weather Association Internet	Ed/train/outreach	Association	NWA	Air Force, others	I	Courses listed in Table 11
NWSTC	National Weather Service Training Center	Ed/train/outreach	NOAA	NWSTC		N	Courses listed in Table 11
OACD	Oceanic Automated Convective Diagnosis Product	Development	FAA	AWRP		F	Provide the cockpit with updated convective weather information over oceanic areas

(continued)

Table 10. Aviation weather programs and projects (continued)

Acronym	Name	Main product[a]	Lead entity[b]	Lead office[b]	Partners	Status[c]	User benefit
OACN	Oceanic Automated Convective Nowcast Product	Development	FAA	AWRP		F	Provide the cockpit with updated convective weather information over oceanic areas
OASIS	Operational and Supportability Implementation System	Decision support	FAA	AUA-400		I	Provide pilots with preflight and in-flight weather information
OCTH	Oceanic Cloud Top Height Product	Development	FAA	AWRP		N	Provide the cockpit with updated convective weather information over oceanic areas
OITFA	Oceanic Integrated Turbulence Forecast Algorithm	Development	FAA	AWRP		F	Provide the cockpit with updated turbulence information over oceanic areas
OPS II	Operational Weather Squadron Production System, Phase II	Dissemination	DOD	Air Force		I	Dissemination of aviation weather products
OPUP	Open Principal User Processor	Development	DOD	Air Force/ Navy		N/F	Graphical user interface for NEXRAD
PA	Polarization Algorithm	Development	FAA	AWRP		F	Detect hydrometeors hazardous to aviation
PCIS	PC-based Icing Simulator	Ed/train/outreach	NASA	SWAP		N	Provide training under simulated icing conditions
PTI	Pilot Training Initiative	Ed/train/outreach	NOAA	NWS		F	Improve pilot interpretation of aviation weather products
PUFF	Volcanic Ash Dispersion Model	Development	DOD	Air Force		I	Dispersion forecasts for volcanic ash
QTP	Qualification Training Packages	Ed/train/outreach	DOD	Air Force		I	Courses listed in Table 11
RADAR	Radio Detection and Ranging	Decision support	NASA	WxAP		N	Early onboard detection of turbulence using radar
RAWS	Remote Automated Weather Sensor	Decision support	DOD	Navy		I	Automated relocatable weather observations
RCWF	Regional Convective Weather Forecast	Development	FAA	AWRP		N	Extended forecasts of regional convection
RUC	Rapid Update Cycle Model	Development	NOAA	AWRP		I	Forecasts of smaller time and space scales or aviation weather hazards
RVR	Runway Visual Range	Decision support	FAA			I	Improve runway visual range reporting
SBID	Satellite-Based Icing Detection	Development	FAA	AWRP		I	Detection of in-flight icing; component of CIP & FIP
S-DARS	Satellite Digital Audio Radio Service (WINCOMM)	Dissemination	NASA		Industry	F	Provide high bandwidth satellite communications to aircraft
SMOOS (R)	Shipboard Meteorological and Oceanographic Observing System Replacement	Development	DOD	Navy		N	Automated weather observations
SVS	Synthetic vision systems	Decision support	NASA	AvSP	Industry, university	N	Enable safe flight under low ceiling and reduced visibility conditions
SWIS	Satellite Weather Information System (WINCOMM)	Dissemination	NASA		Industry	F	Graphical weather information to the cockpit via satellite datalink
SWR	Supplemental Weather Radar	Decision support	DOD	Navy		I	Remote weather radar
TAF	Terminal Aerodrome Forecast Improvements	Development	NOAA	NWS		N	Improve flight safety and efficiency within the NAS

(continued)

TABLE 10. Aviation weather programs and projects (continued)

Acronym	Name	Main product[a]	Lead entity[b]	Lead office[b]	Partners	Status[c]	User benefit
TAM	Tactical Area Met	Development	DOD	NAVY		N	
TAMDAR	Tropospheric Airborne Meteorological Data Reporting	Development	NASA	WxAP		N	Increase number of airborne observations for model analyses and forecasts
TCV	Terminal Ceiling and Visibility	Development	FAA	AWRP		F	Improve ceiling and visibility forecasts for terminal area
TCWF	Terminal Convective Weather Forecast Product	Development	FAA	AWRP	MIT/ Lincoln Labs	N	Improve convective weather forecasts at high traffic density airports
TDWR	Terminal Doppler Weather Radar	Decision support	FAA	ATB 420		I	Detect wind hazards at large airports
TEDS	Tactical Environmental Data Services	Dissemination	DOD	Navy		I	Data assimilation and distribution
TEP	Tactical Environmental Processor	Decision support	DOD	Navy		N	Ship-based Doppler radar
TMOS	Tactical Meteorological Observing System	Decision support	DOD	Air Force		I	Automated observations
TPS	Turbulence Plot System	Dissemination	Industry	Northwest Airlines	ARINC	I	Provide text-formatted messages of weather hazards to commercial aircraft
TWR	Tactical Weather Radar	Decision support	DOD	Air Force		I	Improved radar observations
VAA	Volcanic Ash Avoidance	Ed/train/outreach	Industry	Boeing (producer)	ALPA (distributor)	I	Videotape to train pilots on ash avoidance
VAFTAD	Volcanic Ash Forecast Transport and Dispersion Model	Development	NOAA	OAR		I	Ash dispersion forecasts for hazard avoidance
VAG	Volcanic Ash Graphic	Development	NOAA	NWS	NCEP, ARL, NESDIS	N	Graphical volcanic ash advisory for hazard avoidance
VAP	Volcanic Ash Product	Development	NOAA	NESDIS		N	Improved detection of volcanic ash for aircraft avoidance
VAW	Volcanic Ash Warning	Development	FAA	AWRP		F	Avoid volcanic ash over oceanic areas
VDLM2	VHF Data Link Mode 2	Dissemination	Industry	ARINC		I	Air/ground datalink technology that delivers information at 31.5 kbps
WARP	Weather and Radar Processor	Decision support	FAA	AUA-400	NWS	I	Provide en route weather information for traffic management
WebASD	Web-based Aircraft Situation Display	Decision support	Industry	ARINC		I	Graphical display of hazardous weather conditions
WGPP	Wind Gust Potential Product	Development	NOAA	NESDIS		N	Warn of dangerous wind conditions
WINCOMM	Weather Information Communications	Dissemination	NASA	WxAP	FAA, NOAA, DOD	I	Transmit graphical weather information to the cockpit
WINN	Weather Information Network	Cockpit display	Industry	Honeywell		N	Cockpit display capability for weather information
WMSCR	Weather Message Switching Center Replacement	Decision support	FAA			I	Improve dissemination of weather information
WRF	Weather Research and Forecasting Model	Development	NOAA		NCAR, FAA, NSF, AFWA, Navy, U. of Oklahoma/CAPS, others	N/F	Smaller scale resolution in forecasts of aircraft impact variables now; continuing future improvements in forecasts of aviation weather hazards at storm scale to continental scale

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Table 10. Aviation weather programs and projects (continued)

Acronym	Name	Main product[a]	Lead entity[b]	Lead office[b]	Partners	Status[c]	User benefit
WSDDM	Weather Support to De-Icing Decision Making	Decision support	FAA	AWRP	NCAR	I	Improve safety for de-icing operations
WSP	Weather System Processor (ASR-9)	Decision support	FAA	ATB-420		I	Detect wind hazards in terminal area
WVSS	Water Vapor Sensing System	Development	FAA	AWRP	NOAA, NCAR, airlines	I	Provide moisture input to numerical models
WxITC	Weather-in-the-Cockpit	Dissemination	Industry	Sonalysts, Jeppeson	NASA, NCAR, NWS/AWC, airlines	I	Weather information integration and dissemination to commercial aircraft

[a]Main product types are abbreviated as follows: Development = weather observation/forecast product; Dissemination = weather product dissemination; Ed/train/outreach = education, training, and outreach; Cockpit display = cockpit display system; Decision support = decision support system or capability.

[b]The lead entity corresponds to the program matrix (Tables 5–9) in which the program is shown. Where a federal agency is the lead entity, the lead office is the organizational division within that agency with program responsibility. If the lead entity is an industry, university, or association, the lead office column provides its name.

[c]This column indicates when the program's main product(s) will be implemented and available to end users:
I = already implemented (FY 1997–2002)
N = in implementation now (FY 2003–04)
C = research under a CRA has been completed; product implementation is under way or at discretion of the industry partner
F = future implementation planned or scheduled for FY 2004–07 time frame

Table 11. Aviation weather education and training programs

Lead entity	Program name	Course	Status[a]
AOPA (association)	Aviation Pilot Weather Education	Weather Strategies Seminar	I
		Weather Tactics Seminar	I
		Mountain Flying Seminar	I
		Practical Weather Seminar	I
		"Never Again" Seminar	I
		Operations at Towered Airports Seminar	I
		SkySpotter	I
NWA (association)	National Weather Association Internet Courses	Thunderstorms and Flying	I
		Winter Weather and Flying	I
DOD/AF	Qualification Training Packages	Icing Qualification Training Package	I
		Turbulence Qualification Training Package	I
		Convection Qualification Training Package	I
		Metwatch Qualification Training Package	I
		Flight Weather Brief Qualification Training Package	I
		Volcanic Ash Computer Based Training Module	I
		WSR-88D PUP Operator/Manager Course	I
		Weather Elements Qualification Training Package	I
FAA	FAA Academy Training	Ground De-Icing, Anti-Icing Operations	I
		Low-Level Windshear Alert System	I
		In-Flight Icing	I
		ASOS	I
		METAR/TAF	I
		Basic Aviation Weather	I
		Wake Turbulence	I
		Low-Level Wind Shear/Microburst Alerts	I
		Weather System Processor	I
		Integrated Terminal Weather System	I
		Automated Weather Sensors System	I
		Severe Weather	I
Boeing (industry)	Volcanic Ash Avoidance		I
NASA	Aircraft Operations Systems/Education and Training Program	Icing for General Aviation Pilots (video)	I
		Tailplane Icing (video)	I
		Icing for Regional and Corporate Pilots (video)	I
		A Pilot's Guide to In-Flight Icing (computer-based training)	I
NASA	SWAP	PC-based Icing Simulator	N
NOAA	NWS Training Center Courses	Forecasting Turbulence	N
		Forecasting Icing	N
		Forecasting Low Level Clouds/Fog for Aviation Ops	N
		Low Level Wind Shear	N
		Severe Convection Forecasting and Warnings	N
NOAA	NWS Aviation Operations Course		F
NOAA	NWS Distance Learning Aviation Course	Forecasting Fog and Stratus	N
		Convective Forecasting	F
NOAA	NWS Pilot Training Initiative		F
Kansas (univ.)	Aviation Weather Hazards		I
UCAR-NCAR (university)	Cooperative Program for Operational Meteorology, Education and Training (COMET)	Clouds, Snow, and Ice Using MODIS	I
		Forecasting Icing Type and Severity	I
		Forecasting Radiation Fog	I
		Icing Assessment Using Observations and Pilot Reports	I
		Icing Assessment Using Soundings and Wind Profiles	I
		Radiation Fog	I
		Review of GOES Infrared Imagery Including Winter and Icing Applications	I
		West Coast Fog	I
		Gap Winds	I
		Thermally Forced Circulation 1: Sea Breezes	I
		Thermally Forced Circulation 2: Mountain/Valley Breezes	I
		Forecasting Aviation Icing: Icing Event of 6 March 1996	I

[a]I = already implemented (FY 1997–2002)
N = in implementation now (FY 2003–04)
F = future implementation planned or scheduled for FY 2004–07 time frame