DEPARTMENT OF TRANSPORTATION WEATHER PROGRAMS

The Federal Aviation Administration (FAA) has the responsibility to provide national and international leadership in the optimization of aviation weather systems and services. This leadership is manifested through the management of a safe and efficient National Airspace System (NAS) and the encouragement of consensus and cooperation between government agencies, private weather services, research organizations, and user groups involved in aviation weather. The Federal Highway Administration (FHWA) manages programs that provide federal financial and technical assistance to the states, promotes safe commercial motor vehicle operations, and provides access to and within national forests and parks, native American reservations, and other public lands. Safety, efficiency, and mobility in these programs requires the incorporation and use of timely weather and road condition information. The Federal Railroad Administration is promotes and regulates railroad safety. It also sponsors research to enhance railroad safety and efficiency, including support for improved collection, dissemination, and application of weather information to reduce hazards to train operations and to railroad employees. The Federal Transit Administration mission is to ensure personal mobility and America's economic and community vitality by supporting high quality public transportation through leadership, technical assistance and financial resources. The United States Coast Guard (USCG) meteorological activities include the taking, collection, and transmission of marine and coastal weather warnings and observations; deployment and maintenance of offshore environmental monitoring buoys; and the operation of long-range radionavigation networks.

FEDERAL AVIATION ADMINISTRATION

AVIATION WEATHER MANAGEMENT

The Federal Aviation Administration (FAA) has the leadership role for the national aviation weather program. As the leader, FAA must conduct continual coordination for identifying needs for aviation weather products and services among the Air Traffic Control organization, the aviation industry components and among service providers. The coordination process leads to opportunities to leverage efforts and resources to form partnerships in finding solutions in response to the needs. The *National Aviation Weather Program Strategic Plan* and The *National Aviation Weather Initiatives* are two documents that formalize the coordination and partnerships.

The FAA focus for Aviation Weather has been to promote safety first, then improve the National Airspace System (NAS) efficiency to promote reductions in the delays and re-routing due to weather. The Administrator has launched *The Safer Skies, A Focused Safety Agenda* which includes special analysis teams to evaluate the series of events leading to investigated accidents, and get a sense for what decisions were made in the course of the flight. Other teams, using the findings of the first team, develop intervention actions to eliminate or reduce the causes or improve the actions in the decision making process. Training about the decision making process has been identified by these teams as part of the solution.

Aviation weather information, which is complex and highly perishable, is most useful when customers can successfully plan, act, and respond in ways that avoid accidents and delays. FAA will improve the ability of the aviation community to use weather information through a review and upgrade of airmen training and certification programs. FAA will also develop multi-media training tools to support aviation safety and training initiatives. Funding has been requested to further this effort.

Weather has been made a standard consideration in all aspects of the operation and architecture of the NAS. Aviation weather needs from the field, federal agencies, and industry are entered into the FAA Acquisition Management System (AMS) through which all new programs and changes to the NAS are processed, evaluated, validated, engineered to a requirement, and acquired. The Air Traffic System Requirements Service (ARS) has the responsibility to guide all initiatives through the AMS process and organization, including the Integrated Requirements Team, the Integrated Product Team, and the Decision Boards; to assure the development continues to meet the original need; and to guide the activity should the need be evolving. ARS has added improvements to the AMS process whereby non-system or non-hardware (e.g. service improvement or rule changes) solutions will receive the same rigorous evaluation and validation.

The successful execution of a national aviation weather program is first dependent upon an explicit and mutually understood definition and acceptance of roles and responsibilities both within and outside of the FAA. The execution of these roles and responsibilities have been enhanced by the chartering and complete staffing of the ARS, clarifying FAA lines of business, and completing intra-agency and interagency plans.

FAA relies on other federal agencies for weather services and support, especially NOAA's National Weather Service (NWS) and its Aviation Weather Center. Requirements validated by FAA for domestic and International Civil Aviation Organization (ICAO) users are coordinated annually and supported through the agencies and contractual arrangements. All agencies' efforts in the area of aviation weather services is coordinated for use by all as appropriate. Aviation weather technology includes the ways in which aviation weather information is gathered, assimilated, analyzed, forecast, disseminated, and displayed. The development of this technology also demands that consideration be given to human factors and the application of decision-making tools. FAA will support the use of technology to improve aviation weather information through integration of federal and non-federal resources. Automation, improved product generation, and dissemination to the cockpit offer early opportunities.

AVIATION WEATHER ACQUISITION AND SERVICES

One of the primary functions of the FAA ARS organization is the development and management of requirements for the FAA Capital Investment Plan. Recent projects in the AMS have focused on weather detection and display systems for pilots and air traffic controllers to ensure that aircraft avoid hazardous weather. The following paragraphs describe many of those projects.

The Integrated Terminal Weather System (ITWS) will integrate weather data from sensors in the terminal area to provide and display compatible, consistent, real-time products that require no additional interpretation by controllers or pilots--the primary users. ITWS will use data from automated surface observing systems, Doppler weather radars, and low-level wind-shear alert systems, together with NWS data and products, to forecast aviation impact parameters, such as convection, visibility, icing, and wind shear, including down bursts. Initial capabilities will include sensors available now through the early years of the 21st Century. The development is now in the demonstration phase at several airports in various climatic regimes. There will be 38 ITWSs which will provide displays at 47 high activity airports that are supported by terminal Doppler weather radars. Full production is expected by early calendar year (CY) 2001 (Figure 3-DOT-1).

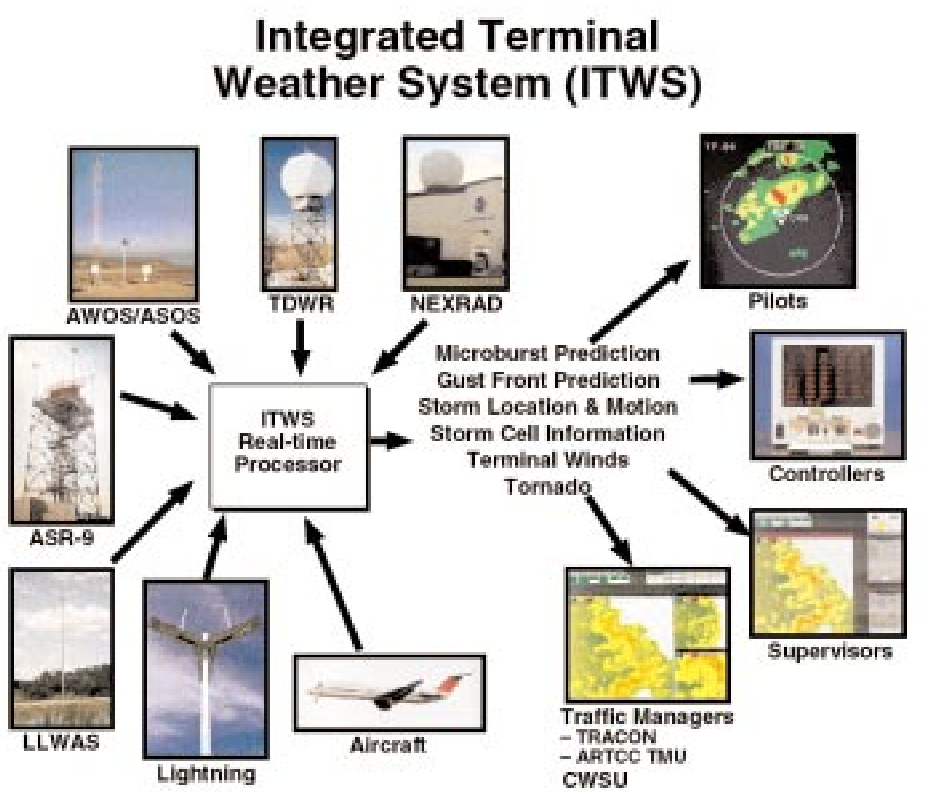


Figure 3-DOT-1. The ITWS will integrate data from FAA and NWS sensors and systems to provide a suite of weather informational products.

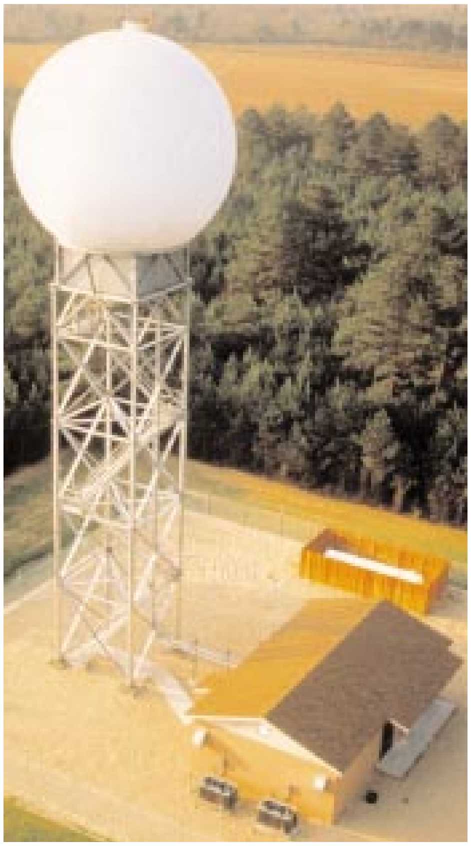


Figure 3-DOT-2. FAA Terminal Doppler Weather Radars provide supplementary wind and precipitation conditions for airport approach and departure.

The Terminal Doppler Weather Radar (TDWR) program consists of the procurement and installation of a new terminal weather radar based on Doppler techniques. TDWR units have been located to optimize the detection of microbursts and wind shear at selected high activity airports. In addition, it has the capability to identify areas of precipitation and the locations of thunderstorms (Figure 3-DOT-2).

Microbursts are weather phenomenon that consist of an intense down draft with strong surface outflows. They are particularly dangerous to aircraft that are landing or departing. TDWR scanning strategy is optimized for microburst/wind shear detection. The radars are located near the airport operating areas in a way to best scan the runways as well as the approach and departure corridors. The displays are located in the tower cab and Terminal Radar Approach Control (TRACON).

FAA has 45 TDWR systems commissioned and the remaining 2 systems will be commissioned by the end of FY 2002. A software upgrade which integrates TDWR and low level wind shear alert system data has been integrated at 9 high traffic/high weather threat airports.

The Low Level Wind Shear Alert System (LLWAS) provides pilots with information on hazardous wind shear that create unsafe conditions for aircraft landings and departures. A total of 110 airports have LLWAS. The 101 basic systems, LLWAS-2, consists of a wind sensor located at center field and 5 to 32 sensors near the periphery of the airport (Figure 3-DOT-3). A computer processes the sensor information and displays wind shear conditions on a Ribbon display to air traffic controllers for relay to pilots. The improvement phase, referred to as LLWAS-Relocation/Sustainment (LLWAS-RS), will include expanding the network of sensors, developing improved algorithms for the expanded network, and installing new information/alert displays. The new information/alert displays will enable controllers to provide pilots with head wind gain or loss estimates for specific runways. These improvements will increase the system's wind shear detection capability and reduce false alarms. Improvements are also expected to reduce maintenance costs. Forty LLWAS–RS are being deployed in CY 2001and the remainder by mid FY 2003.

The Weather Systems Processor (WSP) program provides an additional radar channel for processing weather returns and de-alias returns from the other weather channel in the ASR-9. The displays of convective weather, microbursts, and other wind shear events will provide information for controllers and pilots to help aircraft avoid those hazards. A prototype has been demonstrated and limited production has commenced. Full production deliveries are expected to be completed in FY 2002.

The Terminal Weather Information for Pilots (TWIP) program provides text message descriptions and character graphic depiction of potentially hazardous weather conditions in the terminal area of airports with installed TDWR systems. TWIP provides pilots with information on regions of moderate to heavy precipitation, gust fronts, and microburst conditions. The TWIP capability is incorporated in the TDWR software application. Text messages or character graphic depiction are received in the cockpit through the Aeronautical Radio Incorporated (ARINC) Communication Addressing and Reporting System (ACARS) data link system. A total of 47 TDWR systems will be deployed with 45 of those currently installed and commissioned. The TWIP capability is operational at 31 of the TDWR sites. Activation of TWIP at the remaining sites is dependent on availability of NADIN II connectivity and program funding.

The Flight Information System (FIS) Policy was implemented during FY 2001, through Government-Industry Project Performance Agreements (G-IPPAs) with two industry FIS data link service providers (ARNAV Systems, Inc. and

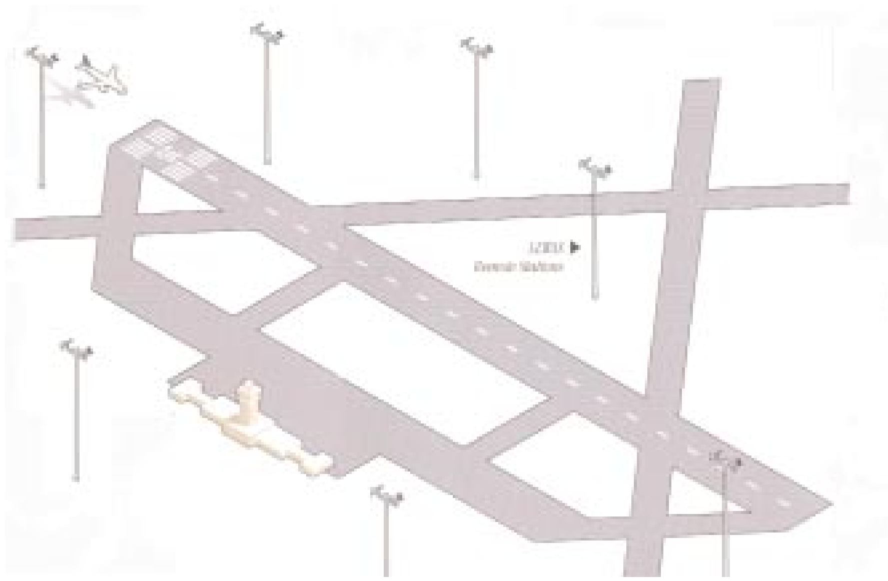


Figure 3-DOT-3. Artists drawing of LLWAS tower positions on an airfield.

Honeywell International, Inc.). Through the government-industry agreements, the FAA provides access to four VHF channels (136.425-136.500) in the aeronautical spectrum while industry provides the ground infrastructure for data link broadcasts of text and graphic FIS products at no cost to the FAA. Under the agreements, a basic set of text products are provided at no fee to the pilot users while industry may charge subscription fees for other value-added text and graphic products.

The FAA FIS data link program will continue development of necessary standards and guidelines supporting inter-operability and operational use. In addition, the need and feasibility for establishing a national capability for collecting and distributing electronic pilot reports (E-PIREPs) from low-altitude general aviation operations is being evaluated. Also, in FY 2001 a concept analysis will be initiated to define the need for transition and evolution of FIS data link services supporting the future NAS architecture including Free Flight operations.

<u>Surface Weather Observing Program</u>

<u>Aviation weather observations</u>. The FAA has taken responsibility for aviation weather observations at many airports across the country. To provide the appropriate observational service, FAA is using automated systems, human observers, or a mix of the two. It has been necessary to place airports into four categories according to the number of operations per year, any special designation for the airport, and the frequency at which the airport is impacted by weather.

- <u>Level D service</u> is provided by a stand-alone Automated Weather Observing System (AWOS) or an Automated Surface Observing System (ASOS). In the future, Level D service may be available at as many as 400 airports.
- <u>Level C service</u> includes the ASOS/AWOS plus augmentation by tower personnel. Tower personnel will add to the report observations of thunderstorms, tornadoes, hail, tower visibility, volcanic ash, and virga when the tower is in operation. Level C service includes about 250 airports.
- <u>Level B service</u> includes all of the weather parameters in Level C service plus Runway Visual Range (RVR) and the following parameters when observed--freezing drizzle versus freezing rain, ice pellets, snow depth and snow increasing rapidly remarks, thunderstorm/lightning location remarks, and remarks for observed significant weather not at the station. Level B service includes about 57 airports.
- <u>Level A service</u> includes all of the weather parameters in Level B service plus 10-minute averaged RVR for long-line transmission or additional visibility increments of 1/8, 1/16, and 0 miles. Level A service includes about 78 airports.

Automated surface aviation weather observing systems will provide aviation-critical weather data (e.g., wind velocity, temperature, dew point, altimeter setting, cloud height, visibility, and precipitation--type, occurrence, and accumulation) through the use of automated sensors. These systems will process data and allow dissemination of output information to a variety of users, including pilots via computer-generated voice.

<u>Automated Weather Observing Systems (AWOS)</u> was deployed at over 200 airports to provide the basic aviation weather observation information directly to pilots approaching the airport. The majority of these systems were installed at various non-towered airports to enhance aviation safety and the efficiency of flight operations by providing real-time weather data at airports that previously did not have local weather reporting capability. These systems are built to the standards of quality necessary to ensure the safety of flight operations and are available off-the-shelf as a commercial product. There remain 198 AWOSs.

<u>Automated Surface Observing Systems (ASOS)</u>. In a joint program with NOAA NWS, the FAA has procured, installed, and operates ASOS at the remaining airports where the FAA provides observations and at additional non-towered airports without weather reporting capabilities in accord with the levels of service listed above. Production is complete and the FAA has 569 systems installed and will have

all commissioned by the end of CY 2001

Aviation Weather Sensor Systems (AWSS), a new program, will have capability similar to ASOS. However, the AWSS is a direct acquisition of the FAA and not from the joint program. Full production may begin in FY2002, pending funding, with commissioning completed in FY 2003.

The AWOS/ASOS Data Acquisition System (ADAS) functions primarily as a message concentrator and will collect weather messages from AWOS and ASOS equipment located at controlled and non-controlled airports within each air route traffic control center's (ARTCC) area of responsibility. ADAS will distribute minute-by-minute AWOS/ASOS data to the Weather and Radar Processor (WARP) within the air route traffic control center in which it is installed. ADAS will also distribute AWOS data to the National Airspace Data Interchange Network (NADIN) which will in-turn forward the data to Weather Message Switching Center Replacement (WMSCR) for further distribution. Field implementation of ADAS has been completed.

The Automated Lightning Detection and Reporting System (ALDARS) is a system adjunct to the ADAS. ALDARS collects lightning stroke information from the National Lightning Detection Network (NLDN) and disseminates this data to AWOS/ASOS for the reporting of thunderstorms in METAR or SPECI observations, when appropriate. The use of ALDARS eliminates the need for manual reporting of thunderstorms and increases the number of airports where thunderstorms will be reported.

Stand Alone Weather Sensors (SAWS) are planned to be back-up for some AWOS/ASOS sensors at locations where no other back-up capability is available. SAWS is in the demonstration phase with full delivery expected in CY 2002.

AWOS for Non-Federal Applications. Under the Airport Improvement Program (AIP), state and other local jurisdictions may justify to the FAA their need to enhance their airport facilities. Upon approval, these improvements may be partially funded by the FAA using resources from the Airway Trust Fund. The local airport authority becomes responsible for the remainder of the funding necessary to complete the procurement as well as the funding for the regular maintenance. The addition of an AWOS is one of the improvements that qualify for AIP funding assistance. Systems that qualify must meet certain standards which are defined in an FAA Advisory Circular on Non-Federal Automated Weather Observing Systems.

There are more than 275 non-Federal AWOS locations. Some of these are capable of reporting through a geostationary communications satellite; many more will acquire that capability during the year. These observations will be entered into the national network for use in support of the NAS and the national weather network.

The New Generation Runway Visual Range (NRVR) program provides for a new generation RVR sub-element of the NAS. The RVR provides runway visual range information to controllers and users in support of precision landing and take-off operations. The new generation RVR incorporates state-of-the-art sensor technology and embedded remote maintenance monitoring. FAA plans to procure and install these RVR systems at all new qualifying locations. FAA plans also call for the replacement of many existing RVRs in the NAS inventory.

The RVR provides for near real-time measurement of visibility conditions along a runway (up to three points along the runway can be measured--touchdown, midpoint, and rollout) and reports these visibility conditions to air traffic controllers and other users. The system automatically collects and formats data from three sensors: a visibility sensor--forward scatter meters will replace the transmissometers currently in use, a runway light intensity monitor for both runway edges and center-line lights, and an ambient light sensor which controls computer calculations using a day or night algorithm. The data processing unit calculates RVR products and distributes the products to controllers and other users.

A total of 528 RVR visibility sensors will be deployed at 264 airports. Delivery of the new RVR sensors began in November 1998. Sixty new RVRs have been fielded with the rest expected by the end of CY 2001. Enhancements are planned to interface with the control tower and the ASOS by mid 2000.

The FAA is procuring the Operational and Supportability Implementation System (OASIS) to improve weather products, flight information, aeronautical data collection, analysis, and timeliness of dissemination and, thereby, enhance the safety and efficiency of the NAS. OASIS will replace the Model-1 Full Capacity Flight Service Automation System, which includes the Aviation Weather Processor. OASIS will also integrate the Interim Graphic Weather Display System functions and include several automated flight service data handling capabilities. This configuration will be its initial deployment capability. Operational testing began in 1999; deployment will commence in FY 2002.

Future enhancements leading to the full capability deployment will include: interactive alphanumeric and graphic weather briefings, direct user access terminal (DUAT) service functionality, automated special use airspace, and training support. OASIS will support flight planning, weather briefings, NOTAM service, search and rescue, and pilot access terminal services.

The Next Generation Weather Radar (NEXRAD), known operationally as the Weather Surveillance Radar-1988 Doppler (WSR-88D), is a multi-agency program that defined, developed, and implemented the new weather radar. Field implementation began in 1990 and was completed in 1996. There are a total of 161 WSR-88D systems deployed. The FAA sponsored 12 systems in Alaska, Hawaii, and the Caribbean. DOC and DOD WSR–88Ds provide coverage over the continental United States.

The FAA emphasized the development of WSR-88D algorithms that take advantage of the improved detection of precipitation, wind velocity, and hazardous storms. The FAA also stressed that these algorithms provide new or improved aviation-oriented products. These improvements in detection of hazardous weather will reduce flight delays and improve flight planning services through aviation weather products related to wind, wind shear, thunderstorm detection, storm movement prediction, precipitation, hail, frontal activity, and mesocyclones and tornadoes. WSR-88D data provided to ATC through the WARP will increase aviation safety and fuel efficiency.

In addition, the three funding agencies support the field sites through the WSR-88D Radar Operations Center (ROC) at Norman, Oklahoma. The ROC provides software maintenance, operational troubleshooting, configuration control, and training. Planned product improvements include a shift to an open architecture, new antenna design, dual polarization, and the development of more algorithms associated with specific weather events, such as hurricanes.

The Air Route Surveillance Radar (ARSR-4) provides the ARTCCs with accurate multiple weather levels out to 200 nautical miles. The ARSR-4 is the first en route radar with the ability to accurately report targets in weather. The ARSR-4 can provide weather information to supplement other sources. The ARSR-4 is a joint FAA/USAF funded project. Forty joint radar sites were installed during the 1992-1995 period.

The Weather and Radar Processor (WARP), Stage 0 has replaced the Meteorologists Weather Processor to provide aviation weather information to the Center Weather Service Units. Stage 1 and 2 will automatically create unique regional, WSR-88D-based, mosaic products, and send these products, along with other time-critical weather information, to controllers through the Display System Replacement and to pilots via the FIS. WARP will greatly enhance the dissemination of aviation weather information throughout the NAS. WARP is currently undergoing operational testing and evaluation and will be fielded at the ARTCCs in FY 2002.

The Direct User Access Terminal (DUAT) system has been operational since February 1990. Through DUAT, pilots are able to access weather and NOTAMs and also file their IFR and/or VFR flight plans from their home or office personal computer. This system will eventually be absorbed into OASIS.

AVIATION WEATHER COMMUNICATIONS

It should be noted that FAA communications systems are multi-purpose. Weather data, products, and information constitute a large percentage of the traffic, as do NOTAMS, flight plans, and other aeronautical data.

The National Airspace Data Interchange Network (NADIN II) packet-switched network was implemented to serve as the primary inter-facility data communications resource for a large community of NAS computer subsystems. The network design incorporates packet-switching technology into a highly connected backbone network, which provides extremely high data flow capacity and efficiency to the network users. NADIN II consists of operational switching nodes at two network control centers (and nodes) at the National Aviation Weather Processing Facilities at Salt Lake City, Utah, and Atlanta, Georgia. It will interface directly to Weather Message Switching Center Replacement (WMSCR), WARP, ADAS, TMS, and the Consolidated NOTAM System. NADIN II also may be used as the intra-facility communications system between these (collocated) users during transition to end state.

The Weather Message Switching Center Replacement replaced the Weather Message Switching Center (WMSC) located at FAA's National Communications Center (NATCOM), Kansas City, Missouri, with state-of-the-art technology. WMSCR performs all current alphanumeric weather data handling functions of the WMSC and the storage and distribution of NOTAMs. WMSCR will rely on NADIN for a majority of its communications support. The system will accommodate graphic data and function as the primary FAA gateway to the NWS' National Centers for Environmental Prediction (NCEP)--the principal source of NWS products for the NAS.

To provide for geographic redundancy, the system has nodes in the NADIN buildings in Atlanta, Georgia, and Salt Lake City, Utah. Each node supports approximately one-half of the United States and will continuously exchange information with the other to ensure that both nodes have identical national databases. In the event of a nodal failure, the surviving one will assume responsibility for dissemination to the entire network.

Currently, specifications for an upgrade or replacement for the WMSCR are being formulated. The needs, when developed, will be entered into the AMS process for validation and acceptance into the NAS architecture.

The Flight Information Service (FIS) is a new communications systems to provide weather information to pilots in the cockpit. FIS is a partnership program among the government and private industry with the government providing the base information and the bandwidth while the private companies provide the broadcast and value-added products. New products are screened for technical suitability and value to the pilots. Two companies have demonstrated preliminary products and capability.

The Worldwide Aeronautical Forecast System (WAFS) is a three geosynchronous satellite-based system for collecting and disseminating aviation weather information and products to/from domestic or international aviation offices as well as in-flight aircraft. The information and products are prepared at designated offices in Washington, District of Columbia, and Bracknell, United Kingdom. The United States portion of WAFS is a joint project of the FAA and NWS to meet requirements of the ICAO member states. FAA funds the satellite communications link and the NWS provides the information/product stream.

Two of the three satellites are funded by the United States. The first is located over the western Atlantic with a footprint covering western Africa and Europe, the Atlantic Ocean, South America, and North America (except for the West Coast and Alaska). The second United States-funded satellite is positioned over the Pacific and covers the United States West Coast and Alaska, the Pacific Ocean, and the Pacific rim of Asia. The third satellite, operated by the United Kingdom, is stationed over the western Indian Ocean and covers the remaining areas of Europe, Asia, and Africa. The data available via WAFS include flight winds, observations, forecasts, SIGMETs, AIRMETs, and hazards to aviation including volcanic ash clouds.

AVIATION WEATHER RESEARCH PROGRAM

Working closely with the Integrated Product Team for Weather/Flight Services Systems, ARW sponsors research on specific aviation weather phenomena which are hazardous and/or limiting to aircraft operations. This research is performed through collaborative efforts with the National Science Foundation (NSF), NOAA, NASA, and the Massachusetts Institute of Technology's Lincoln Laboratory. A primary concern is the effective management of limited research, engineering, and development resources and their direct application to known deficiencies and technical enhancements.

Improved Aircraft Icing Forecasts. The purpose of this initiative is to establish a comprehensive multi-year research and development effort to improve aircraft icing forecasts as described in the FAA Aircraft Icing Plan. The objectives of this plan are to develop: (1) an icing severity index, (2) icing guidance models, and (3) a better comprehension of synoptic and mesoscale conditions leading to in-flight icing. The result of this effort will be an improved icing forecasting capability that provides pilots with more timely and accurate forecasts of actual and expected icing areas by location, altitude, duration, and potential severity.

Convective Weather Forecasting. The purpose of this research effort is to establish more comprehensive knowledge of the conditions that trigger convection and thunderstorms and, in general, the dynamics of a thunderstorm's life cycle. The program will lead to enhanced capability to predict growth, areal extent, movement, and type of precipitation from thunderstorms. Gaining this forecast capability will allow better use of the airspace and help aircraft avoid areas with hazardous convective conditions.

Model Development and Enhancement. This research is aimed at developing or improving models to better characterize the state of the atmosphere and stratosphere in general, with specific emphasis on the flight operation environment specifically, with the aim to provide superior aviation weather products to end users.

Aviation Forecast and Quality Assurance (AF&QA). The Product Development Team for AFGS is working on the development of products for dissemination on the Aviation Digital Data System. New algorithms will be developed to present hazardous conditions in the flight operations environment. They will develop a process for automated production of the SIGMETs. There will be capability to assure quality and a real-time verication process.

Weather Support to Deicing Decision Making (WSDDM). This system develops products that provide forecasts on the intensity of snow and freezing rain, and how or when these phenomena will change in the short term. This information is needed by airport management to determine when an aircraft will require deicing before take-off. The water content of snow is believed to be an important factor. The output product is designed for non-meteorological aviation users and has been demonstrated at three different airports. Development work has been completed and FAA has made this system available to airport authorities who wish to use it as a decision aid.

Ceiling and Visibility. A development and demonstration is underway in the San Francisco Bay area. The project will have unique sensors and the data will be used in new algorithms to develop improved forecasts. The project will continue over a number years as the progress is evaluated. This project is a joint effort with other federal agencies and some of the effort is performed by academic researchers.

Turbulence. In addition to the work being performed by the Joint Safety Analysis Team under the

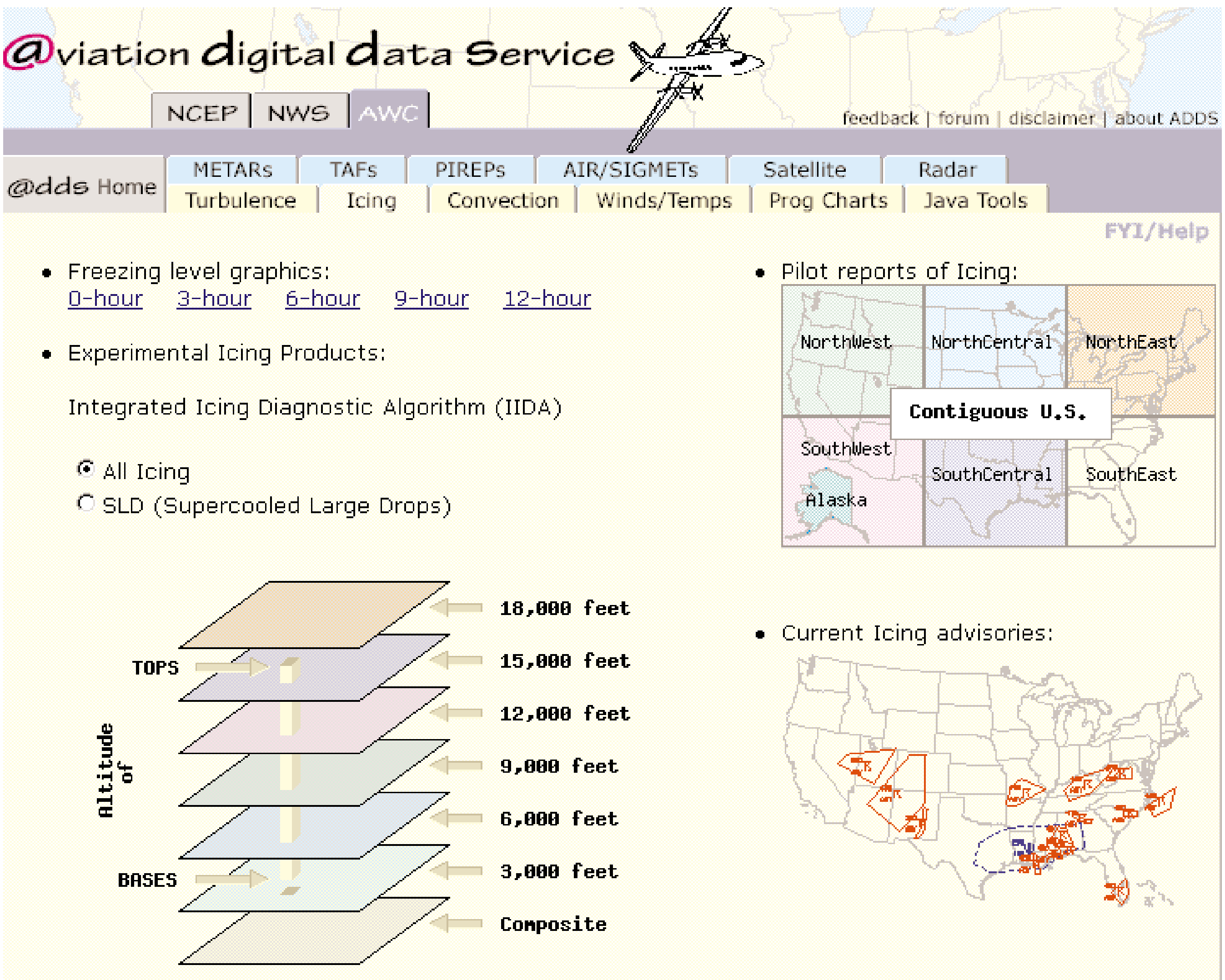
Safer Skies Program, a PDT has a seven year plan to evaluate wind shear and turbulence around and on the approaches to Juneau, Alaska. Also, they are working with certain airlines to install instruments on aircraft with the capability to measure turbulence as sensed on the aircraft and report this information automatically. The data will be used to verify forecasts and to develop a standard index to report and warn for turbulence.

NEXRAD Enhancements. Work is continuing to develop improvements to the existing products and to develop some new graphics. Hardware and software pre-planned product improvements are are being pursued. These efforts are joint among DOT, DOD and DOC.

Space Weather. Space Weather is of concern to the FAA in several areas of operations and regulations. Ionospheric scintillation creates certain errors in the Global Positioning System that affects navigation, especially for instrument approaches to airports. In programs for Wide Area and Local Area Augmentation Systems (WAAS and LAAS) corrections for these effects are being developed. This will be a very important advance to promote the Free Flight management of the National Airspace System. In addition, the effects on the ionosphere have grave impacts on the use of high frequency communications which are essential in air traffic control of flights across the oceans and over the poles of the Earth.

FAA is embarking in research at the Civil Aeromedical Institute in Oklahoma City on the radiation effects on fetuses of newly pregnant women when flying at high altitudes and at high latitudes where exposure is increased. The exposure of flight crews to this hazard will be measured to determine if repeated flights in this regime may accumulate deleterious results.

FAA planners for commercial space operations are working on the weather requirements to set criteria for space launch activities. The commercial launch sites in California, Florida and Virginia are co-located with government sites where the weather support is available. However, at the new commercial space launch site in Kodiak, Alaska new criteria must be developed and established for standard procedures.



FEDERAL PROGRAMS IN SUPPORT OF ROAD WEATHER

Strategic Highway Research Program

The Strategic Highway Research Program (SHRP) was established by the United States Congress through the 1987 Highway Act. In this Act, the Federal government obligated $150 million over five years to improve the performance and durability of our Nation's roads and to make those roads safer for both motorists and highway workers. The SHRP program examined a number of different subject areas, with the winter maintenance efforts falling under the highway operations subject area. Products from this program include specifications, testing methods, equipment, and advanced technologies.

Following the success of this initial, 5-year effort, the FHWA took on the task of coordinating a national program to work with state and local highway agencies to effectively implement and evaluate these products. This phase, entitled SHRP Implementation, was funded through the 1991 Highway Act, entitled the Intermodal Surface Transportation Efficiency Act. This Act obligated $108 million over six years, and was administered by a joint effort between the FHWA, the American Association of State Highway and Transportation Officials (AASHTO), and the Transportation Research Board.

The research program, which was active until 1993, encompassed various technology areas, including Anti-Icing and Roadway Weather Information Systems. The Nation's transportation agencies are currently evaluating and implementing SHRP products. The SHRP Evaluation and Implementation Database (*www.wsdot.wa.gov/fossc/OTA/SHRP/*) contains information on the SHRP Lead States program, SHRP products and vendors, SHRP and other publications, discussion groups, a personnel directory, and a calendar of SHRP-related events. A new research program is being developed to address transportation issues likely to be of concern in the next 20 years.

Intelligent Transportation Systems

While the SHRP program was underway, the Department of Transportation (DOT) was also investing in a significant program aimed at implementing technologies for a host of other transportation challenges, namely the Intelligent Transportation System (ITS) program. Of the many goals of the ITS program, one is to coordinate and deploy some of the SHRP products involving communications and control in winter maintenance. Such implementations are guided by the National ITS Architecture, which provides the framework for road weather system design and information exchange. The development of ITS in the United States is overseen by the ITS Joint Program Office (ITS-JPO) within the DOT. A new user service is being added to the National ITS Architecture that focuses on Maintenance and Construction Operations (MCO), including roadway maintenance and maintenance vehicle fleet management.

Development of Road Weather Information Systems

The efforts following SHRP, as well as the results of the ITS program, have resulted in a host of improvements to treatment of and response to weather in surface transportation. Many of these improvements have been fully evaluated, while others are still evolving or under going further evaluation.

Road Weather Information Systems (RWIS)

SHRP and other FHWA or State DOT programs have identified weather information applications for winter maintenance managers, traffic managers, and emergency managers. RWIS initially referred only to the fixed roadside sensor suites for pavement condition (temperature, chemical concentration, surface water/snow/ice), surface weather observations (temperature, relative humidity, winds, visibility, precipitation), and air/water quality conditions. Figure 3-DOT-4 reflects the widespread deployment of Environmental Sensor Stations (ESS) throughout the United States. Over time, the RWIS definition has broadened to include sensor systems, communication systems, and central analy-

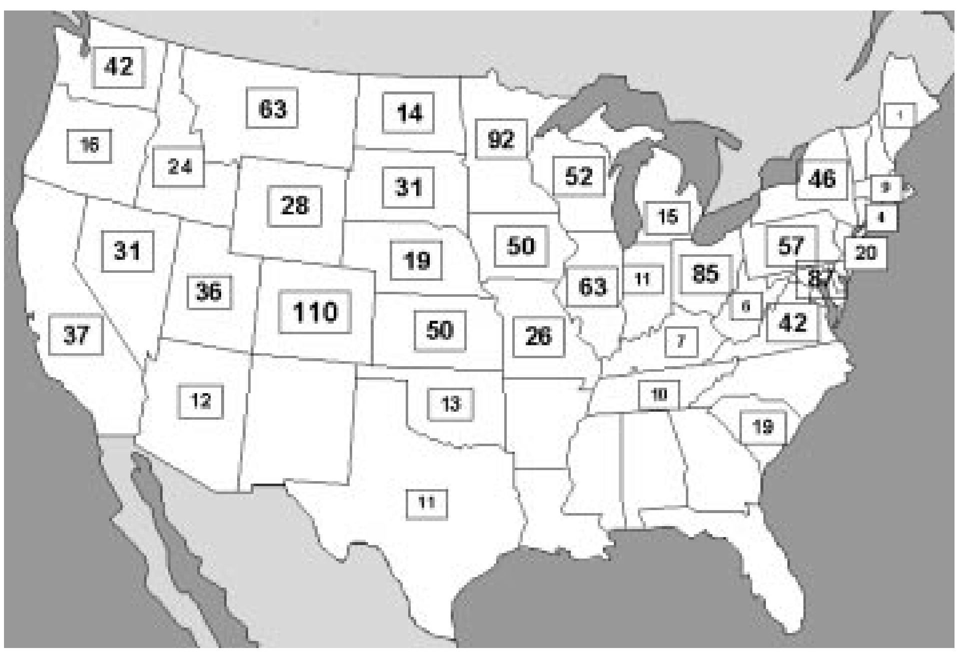


Figure 3-DOT-4. Pavement and ESS Technology Deployment.

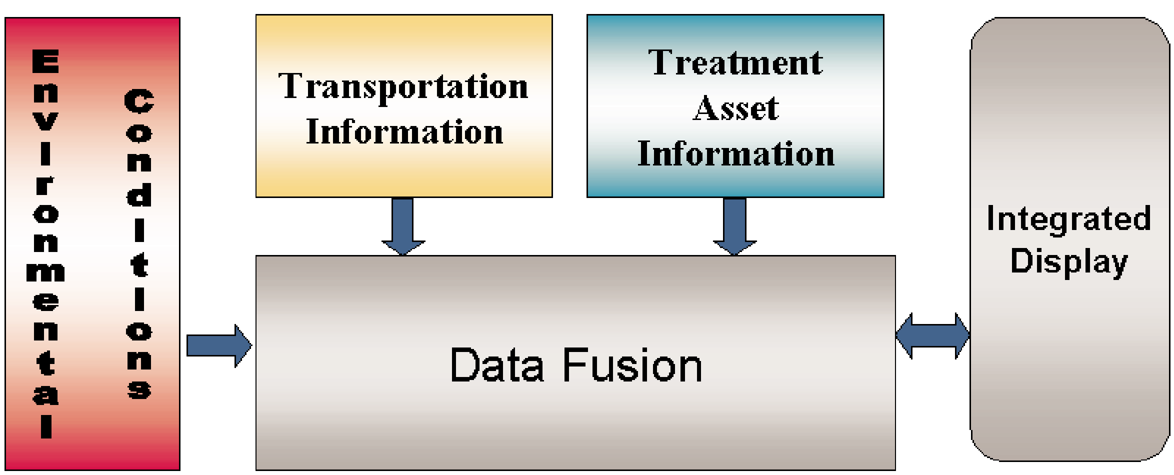
Maintenance Decision Support System (MDSS) Project For the FHWA Road Weather Management Program

The Maintenance Decision Support System (MDSS) project is a multi-year effort to prototype and field test advanced decision support components for winter road maintenance managers. The development of a prototype MDSS is part of the Surface Transportation Weather Decision Support Requirements (STWDSR) initiative conducted by Mitretek Systems, Inc. The documents STWDSR V2.0[1] and the MDSS Project Plan[2] give background information on the project and operational concept for decision support associated with winter road maintenance. These documents explain the process used by the FHWA and stakeholder groups (users, vendors, and researchers) to produce the MDSS prototype.

The MDSS is based on leading diagnostic and prognostic weather research capabilities (high resolution numerical forecast models and experimental algorithms) and road behavior (surface and subsurface), which are being developed at six national research centers. It is anticipated that components of the prototype MDSS system developed by this project will ultimately be deployed by road operating agencies, including state departments of transportation (DOTs), and generally supplied by private vendors.

The MDSS project goal is to develop a prototype capability that: (1) capitalizes on existing road and weather data sources, (2) augments data sources where they are weak or where improved accuracy could significantly improve decision-making tasks, (3) fuses data to create an open, integrated and understandable presentation of current environmental and road conditions, (4) processes data to generate diagnostic and prognostic maps of road conditions along road corridors, with emphasis on the one- to 48-hour horizon (historical information from the previous 48 hours will also be available), (5) provides a display capability on the state of the roadway, and (6) provides a decision support tool that includes recommendations on road maintenance courses of action. All of the above will be provided on a single platform, with simple and intuitive operating requirements in a readily comprehensible display of results and recommended courses of action, together with anticipated consequences of action or inaction.

With user needs in mind, a conceptual structure of the prototype MDSS has been developed. The prototype MDSS is divided into five primary elements as shown in the diagram below.



[1] STWDSR V2.0 Operational Concept Description (*http://www.itsdocs.fhwa.dot.gov/jpodocs/EDLBrow/401!.pdf*) and Preliminary Interface Requirements (*http://www.itsdocs.fhwa.dot.gov/jpodocs/repts_te/@701!.pdf*)
[2] MDSS Project Plan (*http://www.ops.fhwa.dot.gov/weather/mdss.pdf*)

sis systems providing weather information used to improve roadway maintenance and traffic operations, as well as ensure public safety. Consequently, the more precise term for the sensors, both fixed and mobile, is the ESS. The ESS Standard defines protocols for data passage from a roadside sensor or maintenance vehicle to a central processing unit. This observing network is sparse, with about 1,200 remote units covering four million highway route miles. Techniques such as thermal mapping or use of heat value models with ESS data are necessary to extend coverage of road condition information.

Winter maintenance managers have found anti-icing--the pretreatment of roads for better snow removal and ice control--to be cost-effective. Anti-icing relies heavily on RWIS as well as weather and pavement condition products specifically aimed at the highway maintenance community. Traffic managers are able to better manage surface transportation infrastructure and provide information to travelers with RWIS data. For example, traffic signal start-up times may be lengthened under icy pavement conditions or speed limits may be lowered under low visibility conditions. Emergency managers may use RWIS data to make evacuation decisions under hurricane threats.

Advanced Transportation Weather Information System (ATWIS)

Federally supported projects stemming from the first generation SHRP RWIS projects have been important in developing route-specific road condition information. The Advanced Transportation Weather Information System (ATWIS) was developed by the University of North Dakota for North and South Dakota, and the system has recently expanded into Minnesota and Montana. The primary purpose of the ATWIS research program is to demonstrate how current technologies in weather forecasting, weather analysis, telecommunications and road condition monitoring can be merged effectively to produce a safer and more efficient transportation system for both commercial and general travel. ATWIS operates its own meso-scale numerical model, analyzed to road conditions on segments of the Interstate freeway and arterial system in its states. Information is conveyed interactively to travelers, primarily via cell phone.

Key areas of interest of this study include:

- public use and acceptance of road weather information,
- the added value of highly accurate weather forecasts,
- information dissemination methods, and the role of telecommunications,
- the need for 24-hour operations,
- the role of road condition monitoring,
- how to generate efficient forecasts, and
- commercial viability of the system.

ATWIS teams public and private partners to meet the immediate and future needs of rural transportation. As a dynamic Information Service Provider, University of North Dakota's Regional Weather Information Center operates a Transportation Management Center, collecting, analyzing, and providing weather and road condition information to the general public, and State DOTs.

FORETELL

With the intent of integrating RWIS with other ITS services, the FORETELL project was initiated with federal, state, and private funds, in Iowa, Missouri, and Wisconsin. Developing similar capabilities as seen in the ATWIS project, FORETELL focuses more on detailed decision support for road maintenance and the development of heat balance algorithms in combination with its meso-scale numerical modeling. FORETELL is a consortium made up of federal, state, research agencies, and private sector partners from diverse ITS and meteorological backgrounds, that share the common resolve to see detailed road and weather information become an everyday commercial reality.

FORETELL enhances safety and facilitates travel by linking road condition information with other types of traveler information (e.g. incidents, work zones, road closures, etc).

FORETELL's objectives include:

- integrating RWIS across State borders,
- assimilating all of the existing weather and road condition data sources,
- cutting costs and substantially benefiting the environment by increasing the levels of forecasting detail,
- improving timeliness and the accuracy of road weather information, and
- using multiple media for information dissemination.

FORETELL is based on an open-system architecture, which enables ease in evolution and information presentation. Accidents, road closures, congestion, weather conditions, delays, lane closures, current weather conditions are among the many types of information displayed on the web-site.

With FORETELL, highway operating agencies will be able to detect changing conditions sooner and provide advanced warnings and information to the public. Due to increased levels of forecast detail, highway and maintenance professionals will be able to make more informed decisions about the roadway network and more effectively manage resources while maintaining high levels of service. The public will be able to make more specific travel decisions, based on highly detailed road weather information. Additionally, public-public and public-private partnerships will result in improved coordination between FORETELL partners, affiliates and their RWIS and related ITS deployments.

Nationwide Expansion of Road Weather Information

Early results from field operational tests and other experiences have demonstrated encouraging benefits of utilizing technology to develop road weather information. As these systems evolve, a clear pattern of regional services is emerging.

Figure 3-DOT-5 reflects these regional road weather information systems across the United States ranging from the I-95 Corridor Information Exchange Network (IEN) project to *rWeather* in Washington State (sponsored by Washington DOT and the University of Washington). Also included is the Highway Closure and Restriction System (HCRS) developed by Arizona DOT, as well as the traveler information system entitled Condition Acquisition and Reporting System (CARS), which built upon the FORETELL project. Other projects include the ATWIS project in North and South Dakota and Minnesota, the SAFE-PASSAGE project in Montana, the Utah DOT and University of Utah mesonet project, the Southeastern Michigan Snow and Ice Management (SEMSIM) project located in the Detroit the metropolitan area, the OK-FIRST project in Oklahoma, and the Virtual Traffic Management Center in Texas. The Intelligent Road and Rail Information System (IRRIS) is a motorist information system for military movements that is working with Texas to obtain dynamic road condition information. This figure raises a number of questions, for example: (1) should these regional developments limit their geographic scope or should they continue to expand and overlap? (2) how do we ensure that a person driving from one service area to another is able to obtain consistent information? (3) what are the appropriate public and private weather information rates? (4) how can different road condition models be reconciled or combined?

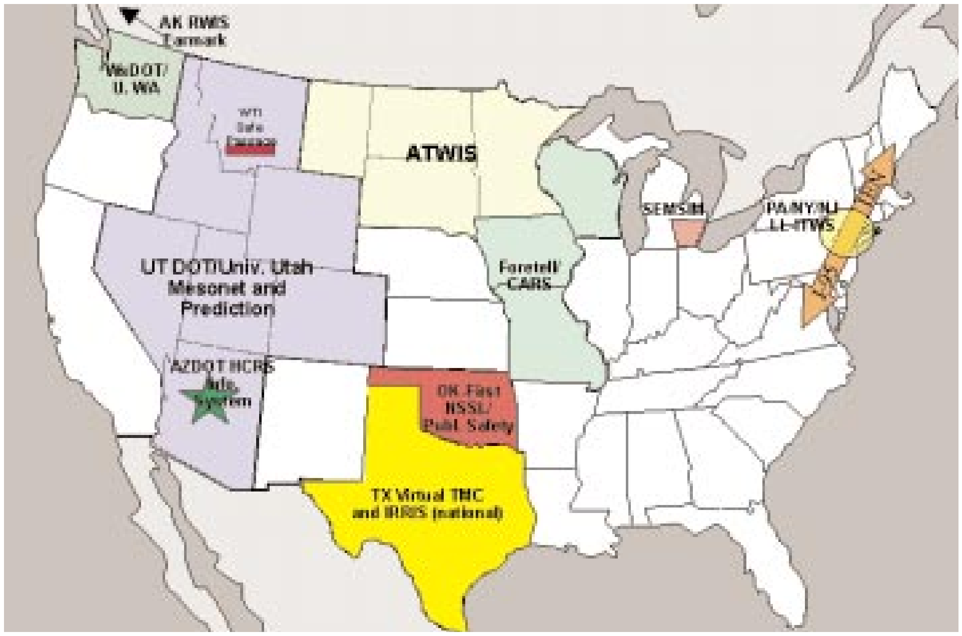


Figure 3-DOT-5 . Regional Weather Information systems.

Current Benefits

The cost savings for a state's highway winter maintenance operations have been achieved due to reduction of personnel overtime costs and decreased use of deicing chemicals and abrasives. For example, Minnesota DOT has calculated a 6:1 to 10:1 return on investment in RWIS for winter maintenance practices. Likewise, RWIS and anti-icing has lead to cost-savings for Wisconsin DOT--the use of RWIS and anti-icing has reduced salt use by 37,500 tons over one season. This reduction equates to approximately $1.1 million saved.

Another example of winter maintenance costs saving was in the state of Indiana, the implementation of the Computer Aided System for Planning Efficient Routes (CASPER). The system is used to assist with the design of routes needed to service the roadway networks based, in part, on road weather conditions. Developers estimate that the equipment and operating cost for winter maintenance has been reduced between $11 million and $14 million.

Improved winter maintenance practices that reduce chemical and abrasive usage also minimize environmental impacts. Dissemination of road weather information to drivers can enhance safety and improve mobility. A Nevada DOT RWIS provides warnings to truck drivers on US 395 when wind gust exceed 30 mph, significantly reducing high-profile vehicle accidents. The Adverse Visibility Information System on Interstate 215 in Utah automatically displays recommended travel speeds based upon prevailing visibility and traffic conditions. In response to advisory messages, overly cautious drivers increase speed causing a 22 percent reduction in speed variation resulting in more uniform traffic flow and reduced accident risk.

FHWA's Road Weather Management Program

The FHWA continues to make road weather management a priority in their transportation operations program. As described earlier, a significant amount of federal dollars have been invested over the course of the last 13+ years. Recent expenditures, on the order of $2 million/year, have also represented a commitment to this program. However, this expenditure represents only a fraction of the amount of money spent on road weather, as the state and local agencies fund a number of their own research and development projects. Such achievements and ongoing efforts are fundamental to achieving our vision, while the goals of the program in support of our vision have been defined as: (1) to develop improved road weather information systems that meet the demands of all users and operators; (2) to develop improved tools and technologies for road weather management and winter maintenance; and (3) to improve traffic operations/incident management procedures for all types of weather events.

By providing weather information that is more accurate and easily understood, outcomes of improved mobility, safety, and productivity will be achieved.

There are many program efforts that need to take place to achieve these goals, and FHWA is central to most of these, either as developer, coordinator, or promoter. The following objectives have been identified in an effort to achieve our goals over the next five years:

- At a national level build consensus and continue to strengthen the relationship between meteorologists and transportation professionals thus providing the leadership for state efforts and creating a common vision for the overall program design.
- Provide improved weather information by developing decision support systems that use better processed weather data and improved weather observation networks to furnish information that is easily interpreted and that adequately combines all types of information that is required to make informed decisions.
- Develop advanced maintenance technologies that are designed to meet the needs of maintenance personnel.
- Develop road weather management practices that define how traffic and incident managers can optimize the performance of their system.
- In coordination with current federal programs, such as Professional Capacity Building and Local Technology Assistance Programs, develop outreach and training course material for program delivery, training, and promotion.

Current and Future Efforts

A number of other research efforts have been completed or are underway to reach our goals and objectives. Perhaps the most significant is our effort to document the road weather decision support requirements needed by end users to support more effective decision making. Such an effort has never been done before, yet is fundamental to all research, development, and testing efforts. Other ongoing efforts include the prototyping of a low cost visibility sensor for the highway environment, and remote sensors for detecting ice on pavements. The FHWA has also worked with our partners to test and evaluate systems that automatically control anti-icing sprayers on bridge decks. As previously mentioned, FHWA has also been instrumental in the FORETELL field operational test.

The Maintenance Decision Support System (MDSS) project is a multi-year effort to prototype and field test advanced decision support components for winter road maintenance. The prototype development phase is being conducted by a team of six national research laboratories with expertise to winter road maintenance decision support. This effort will lead to an operational test of the MDSS, as well as produce decision support components that private vendors can incorporate into their products for maintenance managers.

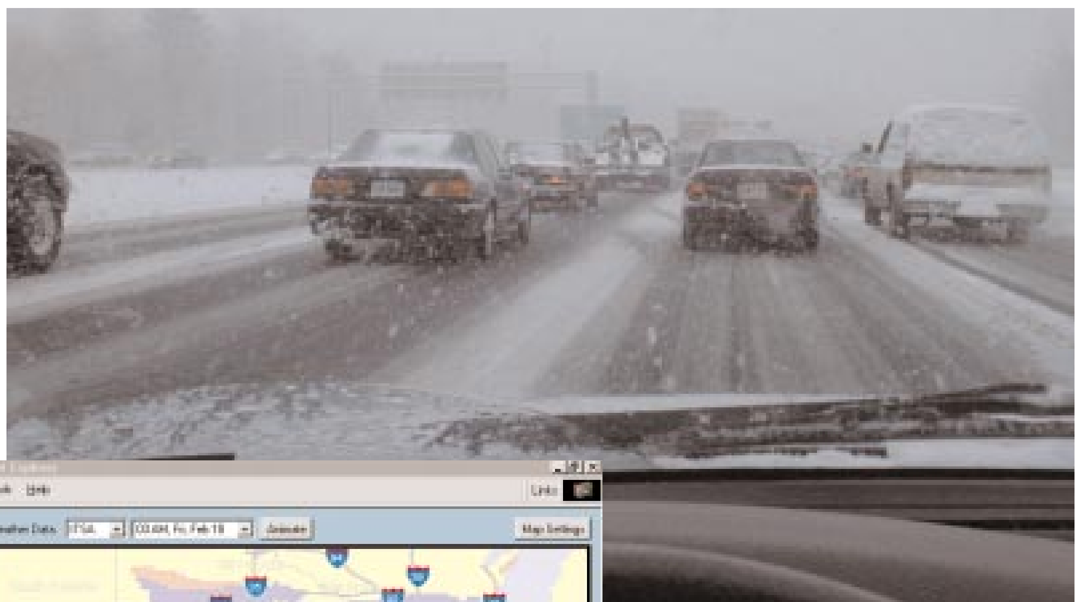
Future efforts will focus on all technical aspects of the road transportation system, including weather data collection, processing and dissemination, as well as the institutional challenges surrounding system implementation. The institutional challenges include coordination within state and local DOTs, such as between maintenance and travel management offices, as well as across the transportation and meteorological communities. With regard to technical areas of interest, data collection efforts will include optimizing ESS siting, as well as incorporating road weather observational data, such as pavement and subsurface observations, into broader meteorological observation networks. Better processing includes the application of higher resolution weather models, and the development of other road condition prediction models (e.g. heat balance models) that are needed to develop the appropriate weather information. Such products will be incorporated into decision support systems, whose design is based on the current efforts to document road weather decision support requirements. Development of such systems requires strong inter-federal coordination between the transportation and meteorological communities.

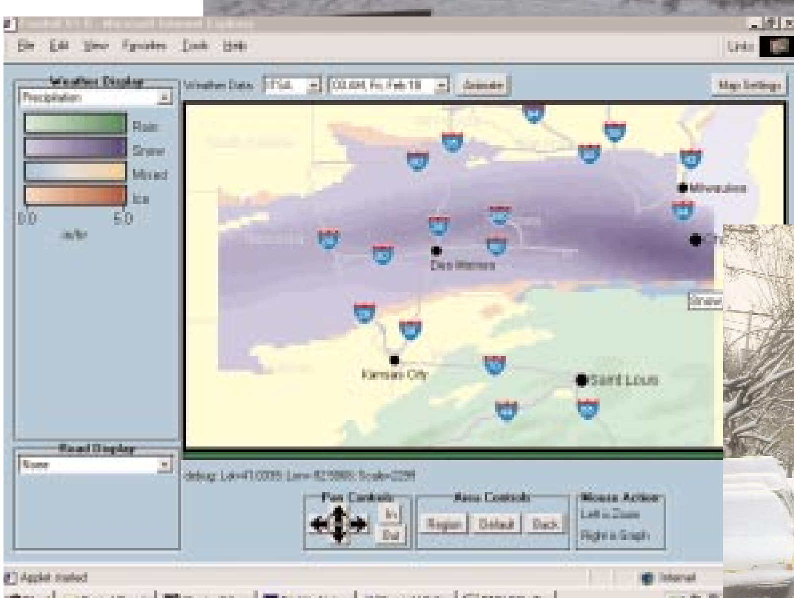
With respect to implementation, it is important to note that unlike the FAA, FHWA is not a modal operating agency, and it represents many constituents, such as state, cities and local governments. FHWA will take the lead in initiating efforts, such as defining road weather decision support requirements, and prototyping decision support systems. However, the success of this program largely depends on the efforts of the operating agencies, as well as the coordination across the transportation and meteorological communities. Therefore, it is expected that the results of these efforts will lead the owners and operators of the nation's highways, the state and local DOTs, to invest in the implementation of these systems nationwide.

National Coordination

In order to achieve the maximum benefit and desired output from this program area there must be a mutual interest and commitment across the transportation and meteorological communities. Currently, efforts to develop weather information systems for surface transportation are moving forward. These efforts are complicated by the need for significant coordination between the transportation and meteorological communities--to date the two communities have had little direct interaction on a national level. As this working relationship builds, it has become evident that the meteorological community must have a clear idea of the surface transportation weather requirements in order to respond with the appropriate products and services. Consequently, the transportation community must articulate it's needs, and in a manner that enables the meteorological community (both public and private) to respond. Likewise, the meteorological community must be committed to helping resolve the problems that weather inflicts upon the surface transportation system.

Continued national-level consensus building will be necessary both to provide leadership for state efforts and to create a common vision for the overall program design. It is important to coordinate our efforts with others, as it ensures that we are not duplicating effort, while also keeping our goals and objectives focused on the needs of our constituents. The most apparent groups to link to include: federal, state and local agencies both in the transportation and meteorological communities, standards development organizations, and national committees and associations dealing with surface transportation weather and winter mobility. To date there have been some significant achievements, such as the formation of the OFCM Joint Action Group for Weather Information for Surface Transportation (JAG/WIST), and FHWA--FEMA coordination for hurricane evacuation. However, this is only considered the first of many successful partnerships. The FHWA looks forward to building upon these successes to achieve the needed improvement to the highway environment.





The Federal Railroad Administration (FRA) supports improving the collection, dissemination, and application of weather data to enhance railroad safety through the Intelligent Weather Systems project, as part of the Intelligent Railroad Systems and Railroad System Safety research programs. These programs address safety issues for freight, commuter, intercity passenger, and high-speed passenger railroads.

Intelligent Weather Systems for railroad operations consist of networks of local weather sensors and instrumentation - both wayside and on-board locomotives - combined with national, regional, and local forecast data to alert train control centers, train crews, and maintenance crews of actual or potential hazardous weather conditions. Intelligent weather systems will provide advance warning of weather-caused hazards such as flooding; track washouts; snow, mud, or rock slides; high winds; fog; high track-buckling risk; or other conditions which require adjustment to train operations or action by maintenance personnel (Figure 3-DOT-6). Weather data collected on the railroad could also be forwarded to weather forecasting centers to augment their other data sources. The installation of the digital data link communications network is a prerequisite for this activity.

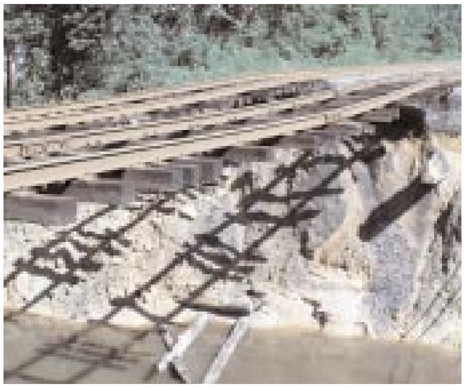


Figure 3-DOT-6. Track trussel washed out by flood waters.

FRA intends to examine ways that weather data can be collected on railroads and moved to forecasters, and ways that forecasts and current weather information can be moved to railroad control centers and train and maintenance crews to avoid potential accident situations. This research is estimated to continue for 5-6 years after it begins. This is one of the partnership initiatives identified in the NSTC's *National Transportation Technology Plan*.

The Federal Transit Administration's (FTA) mission is to "*provide leadership, technical assistance and financial resources for safe, technologically advanced public transportation which enhances all citizens' mobility and accessibility, improves America's communities and natural environment, and strengthens the national economy*." In this context, FTA provides an energy efficient means of transporting people, thereby, reducing emissions caused by transportation and lessening the Nation's dependence on fossil fuels, including foreign oil. One-hundred gallons of fuel can be saved each year for every person riding the bus instead of driving. The savings by train and trolley riders are even greater.

The United States Department of Transportation (DOT) has a variety of research development and demonstration programs and initiatives that are targeted at reducing the emissions and improving the efficiency of vehicles including trucks, buses, marine vessels, airport support equipment, and other specialty vehicles. The underlying assumption of many of these public-private partnership efforts is to improve current vehicles without sacrificing vehicle performance or limiting consumer choices in the marketplace.

Figure 3-DOT-7. Protoype of FTA's electric bus program.

In particular, the FTA Fuel Cell Transit Bus Program and the Hybrid Electric and Electric Bus Program (Figure 3-DOT-7) focus on developing and demonstrating innovative transit bus technologies that can improve the energy efficiency and reduce harmful emissions from transit buses, including greenhouse gas emissions. Through these efforts, the benefits and viability of both fuel cells and hybrid electric drive technology for transit bus applications are being demonstrated.

Similarly, the Advanced Vehicle Technologies program (AVP) managed by DOT, is a collaborative program between the Federal government and over 500 companies, universities, national laboratories, state, regional, and local governments focused on innovative technologies for medium and heavy-duty vehicles that can lessen the transportation sector's dependence on foreign oil, reduce emissions from transportation vehicles, and enhance the development of a domestic advanced transportation industry. The technologies developed and demonstrated under the program are closely related to transit research needs, or directly develop and demon sate advanced technologies for transit.

The Transit Cooperative Research Program is currently researching FTA's role in avoiding greenhouse gas emissions. Project H-21 is examining how transit service can contribute to community sustainability and provide enhanced mobility while addressing climate change at the community and regional level.

One example of research for vehicle emissions is with the Desert Research Institute (DRI) to develop and test a new remote sensing device that accurately estimates particulate emissions from motor vehicles and will quantify the contributions of ozone precursor and small particular emissions from sources outside the Las Vegas metropolitan area. The meteorological and air quality modeling will attempt to quantify the level of emissions transported into the area from the Los Angeles South Coast Air Basin.

In FTA's national rural and parks programs coordinated with the research efforts currently underway with the Weather Information for Surface Transportation (WIST) initiative. This research will take advantage of other related rural ITS weather resources to integrate transit and emergency services through the "Common Communication Backbone Concept." Many rural areas can greatly benefit from a Joint Operational center that consolidates transit management, emergency management, and emergency medical service operations utilizing light rail, ferry, van, and bus transit services. This integrated management and transit emergency service will enable rural transit operators to manage weather-related incidents more efficiently, while improving the coordination with travelers and emergency management staffs (Figure 3-DOT-8.).

Figure 3-DOT-8. Weather poses a significant impact on transit operations in the Washington metropolitan area. (WMATA Photograph)

Although no United States Coast Guard (USCG) cutters or shore units are solely dedicated to meteorology, they collectively perform a variety of functions in support of the national meteorology program. USCG ocean-going cutters and coastal stations provide weather observations to the National Weather Service (NWS). Coast Guard communications stations broadcast NWS marine forecasts, weather warnings, and weather facsimile charts and, also, collect weather observations from commercial shipping for the NWS. The Coast Guard also operates the LORAN C radionavigation system and the Maritime Differential GPS (DGPS) Service. The LORAN C system provides Position, Navigation, and Timing (PNT) information to a variety of navigation and non-navigation users throughout the continental United States and Alaska (e.g. radiosondes). The Maritime DGPS Service is an augmentation to the GPS that improves GPS-only accuracy to better than ten meters and provides DGPS coverage to coastal areas of the continental United States, the Great Lakes, Puerto Rico, portions of Alaska and Hawaii, and portions of the Mississippi River Basin.

USCGC HEALY, a new icebreaking research vessel, was delivered to the Coast Guard in November 1999 and conducted successful shakedown tests of the hull, machinery, and scientific equipment during January-August 2000 (Figure 3-DOT-9). The first unrestricted science cruise is scheduled for the Eastern Arctic in the summer of 2001. HEALY, has a length of 420 feet, beam of 82 feet, and displaces over 16,000 tons. Scientific systems and gear include a bottom mapping multi-beam sonar system; a sub-bottom profiling system; a conductivity-depth-temperature data system; an expendable oceanographic probe system; an Acoustic Doppler Current Profiler; a jumbo coring system; a continuous flow, seawater sampling system; a meteorological measurement system; and a bow tower for clean air experiments. To schedule time on HEALY, see the UNOLS web site, *http://gso.uri.edu/unols/unols.html*. For more information, see the Coast Guard web page for HEALY, *http://www.uscg.mil/pacarea/healy/*.

Figure 3-DOT-9. USCGC HEALEY, the Coast Guard's new icebreaking research vessel, conducting ice trials.

USCG maintains the International Ice Patrol (IIP) which uses sensor-equipped aircraft to patrol the Grand Banks of Newfoundland to locate and track icebergs which pose a hazard to North Atlantic shipping. Direct observations are supplemented and extrapolated using a numerical iceberg drift and deterioration model. IIP determines the geographic limits of the iceberg hazard and, twice daily, broadcasts iceberg warning bulletins and ice facsimile charts which define the limits of the iceberg threat during the iceberg season (spring and summer). IIP annually archives data on all confirmed and suspected targets, and forward these data to the National Snow and Ice Data Center. These data can be accessed via the IIP web page *www.uscg.mil/lantarea/iip/home.html*. Archived data contains all iceberg sighting data along with the last model-predicted position of each berg.

The Coast Guard participates with the Navy and NOAA in conducting the National Ice Center, a multi-agency operational center that produces analyses and forecasts of Arctic, Antarctic, Great Lakes, and coastal ice conditions.

The Coast Guard also collaborates with NOAA in operating the National Data Buoy Center (NDBC) which deploys and maintains NOAA's automated network of environmental monitoring platforms in the deep ocean and coastal regions. Five Coast Guard personnel fill key technical and logistics support positions within NDBC. Coast Guard cutters support the deployment and retrieval of data buoys, and provide periodic maintenance visits to both buoys and coastal stations, expending approximately 180 cutter days annually. Coast Guard aircraft, small boats, and shore facilities also provide NDBC support.

Meteorological activities are coordinated by the Icebreaking Division of the Office of Aids to Navigation at Coast Guard Headquarters. Field management of Coast Guard meteorological support services is accomplished as the Coast Guard Area and District levels.