

AN OVERVIEW OF FEDERAL HIGHWAY ADMINISTRATION ROAD WEATHER MANAGEMENT PROGRAM ACTIVITIES

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1. INTRODUCTION

Weather threatens all of the nation's roads on every day of the year by affecting pavement friction, roadway infrastructure, vehicle maneuverability, and driver capabilities. The Road Weather Management program of the Federal Highway Administration (FHWA) seeks to understand weather impacts on roads and promote techniques to improve roadway operations in inclement weather. This paper presents an overview of program objectives, various research and outreach projects, as well as tools used by traffic, emergency and maintenance managers.

2. PROGRAM OBJECTIVES

The vision of the Road Weather Management program is to minimize weather impacts on roads by addressing all FHWA strategic goals, as shown in Table 1.

**Table 1 – FHWA Strategic Goals
& Program Objectives**

Strategic Goals	Road Weather Management Program Objectives
Safety	Reduce crashes due to weather and poor pavement conditions
Mobility	Reduce traffic congestion and travel time delay during inclement weather
Productivity	Decrease road operating and maintenance costs associated with adverse weather, and minimize weather impacts on freight operations
Environment	Minimize impacts of road treatment activities on air, soil, and water quality
National Security	Facilitate coordinated response, improve evacuation operations, and support military movements

Weather impacts roadway safety by increasing crash risk and exposure to hazards. Traffic speeds and roadway capacity (i.e., the maximum rate at which vehicles can travel) can be reduced by weather impacting roadway mobility or level of service. Transportation system productivity is affected when access to roadway networks is disrupted or operating and maintenance costs are increased by weather.

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Snow and ice control techniques include the application of millions of tons of salt and sand to road surfaces each year. These and other chemicals threaten the environment when residues on pavements run off and contaminate surface and ground water, soil, and vegetation. Abrasives (e.g., sand) also contribute to airborne particulate pollution when silt fractions are high or when they crumble under tire loads.

Weather influences the dispersion of pollutants and hazardous materials including nuclear, chemical and biological releases. Understanding dispersion processes can enhance efforts to ensure national security. Road weather information is also critical to the movement of military resources on the National Highway System.

The FHWA Office of Operations has made road weather management a priority. Road Weather Management program objectives include:

- Quantifying weather impacts on FHWA strategic goals;
- Improving environmental observing systems to provide roadway operators and users with data needed to make informed decisions;
- Developing and advocating advanced tools and operational techniques for traffic managers, emergency managers, and winter maintenance managers in response to weather;
- Facilitating a robust, competitive market for road weather services; and
- Promoting a formal road weather research program across constituencies by strengthening relationships between meteorological and transportation professionals.

2.1 National Road Weather Observing System

Effective road weather management strategies require accurate, relevant, and timely road weather information. This information consists of both transportation and meteorological information, which must be integrated and presented to decision makers in a manner that is easy to interpret and act upon. Providing this integrated information starts with pertinent weather observations. Transportation managers utilize observations and predictions of environmental conditions to make decisions about resource

deployment and system operation. Information about weather and pavement conditions is typically gathered through surveillance systems that transmit roadway data to central management systems.

Over 1,300 Environmental Sensor Stations (ESS) have been deployed by state and local agencies across the country to provide transportation managers with information on current conditions. ESS may be configured to detect atmospheric (e.g., air temperature, visibility, wind speed), pavement (e.g., dry, wet, icy, chemical concentration), subsurface (e.g., frozen, thawed), water level, and slope stability conditions (e.g., landslide or avalanche onset). Most ESS are roadside components of Road Weather Information Systems (RWIS) that collect, transmit, process, and disseminate environmental data. Road weather data may be used in automated motorist warning systems, traffic management centers, road maintenance facilities, and emergency operations centers. Both public and commercial weather services may also use road weather data to enhance forecasts and develop customized products (e.g., pavement temperature prediction profiles).

Integrating ESS information with the national observing capabilities of the National Weather Service (NWS) and others would maximize the benefits of public investments in RWIS. The Road Weather Management program advocates a national road weather observing system that promotes open data sharing, analysis, and integration to support transportation operations. As part of the *National Highway System "Infostructure"* initiative the Road Weather Management program is also examining the minimum number of ESS required in major metropolitan areas and projecting national deployment costs.

The FHWA is working with the Office of the Federal Coordinator for Meteorology (OFCM) to establish national weather information requirements and to improve interagency coordination and cooperation. In 1999 and 2000, *Weather Information for Surface Transportation (WIST)* symposia were held to identify, compile, and analyze user needs and to foster development of decision support capabilities. Participants represented federal, state, and local governmental agencies as well as private sector interests in six surface transportation sectors. The FHWA is also a member of OFCM's *Committee for Integrated Observing Systems (CIOS)*, which aims to optimize and integrate global weather observations (i.e., atmospheric, terrestrial, oceanic, space). The CIOS addresses policies, programmatic activities, and technical issues associated with national environmental observing networks. In support of CIOS, the FHWA has initiated a data gap analysis with respect to integrated observing.

Providing the types of services to road users and operators that will improve highway operations is as dependent on the NWS modernization as it is on

Intelligent Transportation Systems (ITS). ITS apply information technology to the transportation system to improve all types of operations, not just those associated with adverse weather. Consequently, success is contingent upon the integration of road weather information into both ITS and meteorological systems (e.g., mesonets). Information integration requires data standards that define how system components are connected and how they operate in a common structure or architecture. Standards facilitate data sharing and enhance the interoperability of sensors. Siting standards for ESS ensure that desired conditions are detected at the optimal location. Calibration standards compare sensor accuracy with established performance criteria in laboratory settings (i.e., initial calibration), after field deployment (i.e., on-site calibration), and over time (i.e., recalibration as part of routine maintenance) (FHWA 2002).

Future developments in road weather observing include mobile and remote sensing capabilities. In cooperation with the Center for Transportation Research and Education and private sector partners, the FHWA is exploring advanced maintenance vehicles with mobile sensors to measure air temperature, pavement temperature, and road friction; as well as Global Positioning System (GPS) technology to monitor vehicle location and status.

The FHWA is also working with the Forecast Systems Laboratory of the National Oceanic and Atmospheric Administration (NOAA) to demonstrate how remote sensing can improve precipitation forecasting. Differential GPS, or DGPS, measures satellite-to-ground signal delays caused by water vapor in the atmosphere. Integrated precipitable water vapor (IPWV) is an estimate of the amount of moisture contained in a column spanning the height of the atmosphere. This kind of information can be used to approximate the precipitation potential from storms. DGPS-IPWV observations can improve the accuracy of relative humidity predictions, precipitation type forecasts, and quantitative precipitation amount projections. (Nelson, Persaud 2002)

2.2 Advance the State-of-the-Practice

Environmental impacts on roads are mitigated through informational and operational integration. Better information about impending and existing weather threats leads to better decision-making by transportation managers who employ mitigation strategies to minimize weather impacts on roadways. Improved information also enables road users (e.g., commuters, transit operators, truck drivers) to make better travel decisions (e.g., route choice and travel speed). Operational integration involves cooperation of traffic, emergency and maintenance managers across agencies and jurisdictional boundaries. The FHWA is involved in numerous projects that advance the state of these road weather management practices. Some of these projects are:

- The *Cooperative Program for Operational Meteorology, Education, and Training (COMET)* program, which awarded five research grants in 2001 for collaborative research among universities, NWS forecasters, and state Department of Transportation (DOT) personnel. The research focused on ESS applications, data assimilation, and road condition forecasting.
- The *Advanced Transportation Weather Information System (ATWIS)*, which began with university research and has grown into a private venture. Drivers in Minnesota, Montana, North Dakota, and South Dakota can access ATWIS by dialing #7233 (or #SAFE™) to obtain six-hour weather forecasts and route-specific road condition reports.
- *FORETELL™*, which was the first Road Weather Management program field operation test awarded in 1997, is a multi-state initiative to create an RWIS that is fully integrated within a wider set of ITS services.
- The *Surface Transportation Weather Decision Support Requirements (STWDSR)* project was initiated in 1999 to document information requirements to improve highway performance under weather threats. STWDSR V1.0 compiled 426 types of decisions across 44 decision maker categories. STWDSR V2.0 defined an operational concept and specified preliminary interface requirements of an advanced decision support system for winter maintenance managers. STWDSR V3.0 extended the analysis with a focus on travelers and the operational techniques of traffic managers and emergency managers.
- The *Maintenance Decision Support System (MDSS)* project, which began in 2000, is being conducted by a partnership of five national laboratories, various state DOTs, and several private vendors. A prototype system has been developed and is currently being demonstrated in Iowa DOT maintenance garages. Following demonstration and evaluation, the prototype will undergo further development in an operating environment.
- The *U.S. DOT ITS Standards Program* has developed the National Transportation Communications for ITS Protocol (NTCIP), which is a family of standards defining the communication rules and vocabulary necessary to facilitate interoperability of roadside equipment from different manufacturers. The ITS Standards include protocols and data object definitions for roadside-to-management center communications, and message sets for disseminating road weather information to managers or travelers.

The Road Weather Management program also coordinates with other federal programs (e.g., ITS Professional Capacity Building, Local Technology

Assistance Programs) to develop outreach materials, deliver training courses, and promote the best management practices. Through the National Highway Institute, the program is offering a “*Fundamentals of Road Weather Management*” course to transportation professionals. Course content includes the scope of the road weather problem and associated costs, basic meteorology, effective mitigation strategies, and technical and institutional challenges.

In August 2002, the program released the “*Best Practices for Road Weather Management*” CD-ROM, which contains resources to help traffic, emergency, and maintenance managers improve roadway operations in adverse weather. It includes case studies of advisory, control, and treatment strategies employed in response to fog, high winds, rain, snow, ice, flooding, tornadoes, hurricanes, and avalanches. The CD also includes a listing of road weather publications and online resources.

2.3 Formal Surface Transportation Weather Research Program

Current resources to promote and sustain road weather research are inadequate, undedicated, and limited by current authorization levels. There is a need for a well-established, formal research program with dedicated funding to address the needs of all constituencies. To achieve this, the program must first demonstrate the value of road weather management (i.e., projected benefits of such a program), develop an organizational structure, define the research agenda, and determine funding levels.

Once established, a national steering committee of transportation, public safety, and meteorological professionals would present opportunities for interdisciplinary, interagency, and public-private cooperation. A national research agenda would include advanced weather research, applied research (e.g., develop integrated solutions), technology transfer efforts, and architecture and standards activities. The success of the Aviation Weather Research Program has shown that dedicated funding can significantly reduce the impact of weather on aviation operations (FAA 2002). It is believed that a similar approach for surface transportation would yield comparable benefits.

The following sections provide more detailed descriptions of efforts aimed at advancing the state-of-the-practice in the areas of traffic management, emergency management, and winter maintenance management.

3. TRAFFIC MANAGEMENT

There are a number of tools and techniques under development or available to traffic managers to mitigate weather impacts. Traffic managers may utilize commercial or customized road weather data to manage traffic flow and disseminate traveler information from

traffic management centers (TMCs). Managers can modify traffic signal timing plans and freeway incident detection algorithms to optimize traffic flow based upon prevailing weather conditions. Managers may notify drivers of safe travel speeds or reduced speed limits with Variable Speed Limit signs and Dynamic Message Signs (DMS). Ramp gates, highway advisory radio, lane use signs, flashing beacons, and DMS are also controlled by traffic managers to alert motorists to hazards and to restrict access to specified lanes or bridges, entire road sections, designated vehicle types (e.g., tractor-trailers), vehicles without required equipment (e.g., snow tires), or all vehicles. Traveler information furnished by traffic managers allows motorists to make decisions about departure time, route selection, vehicle type, and driving behavior.

In addition to roadway motorist warning systems, traffic managers disseminate textual and graphical road weather information via the Internet and telephone systems. Managers exploit interactive voice response technology to furnish pre-trip and en-route information through toll-free telephone numbers and the national traveler information telephone number—511, which was allocated by the Federal Communications Commission in 2001. The program is coordinating with the 511 working group to establish road weather data requirements.

Part of the Road Weather Management program is aimed at determining the most effective ways to implement these solutions, and promoting them to encourage implementation by practitioners. In addition, there is a need to develop system-wide solutions that complement site-specific solutions. In this regard, work is underway to analyze the impacts of weather on highway capacity (i.e., travel time delay) and driver behavior, and to draft concepts of operation for weather-responsive traffic management.

4. EMERGENCY MANAGEMENT

The large increase in coastal populations without any significant increase in roadway lane-miles means that traffic management could become the weak link in the hurricane evacuation chain. In January and February 2002, the program held three regional workshops in the southeastern United States to explore ways to improve traffic operations during hurricane evacuations. Workshop participants were from transportation, law enforcement, and emergency response agencies in Alabama, Florida, and Georgia; North Carolina, South Carolina, and Virginia; as well as Louisiana and Texas. The Road Weather Management program hopes to facilitate information sharing, instrumentation and technology deployment, integration of traffic and weather models for evacuation, and development of guidance for traffic managers. The FHWA has initiated a grant program to improve coordination of traffic managers and emergency managers in southeastern states during the 2002 hurricane season. The planning grants are intended to

improve multi-state, multi-agency operations by addressing institutional, operational, and technological issues.

In concert with the Federal Emergency Management Agency (FEMA), FHWA is working to support regional hurricane response efforts through the *Evacuation Liaison Team (ELT)* by facilitating information exchange between federal and state emergency management officials. FHWA, FEMA and the U.S. Army Corps of Engineers have also sponsored development of the *Evacuation Traffic Information System (ETIS)*, which is a web-based application with the capability to ingest traffic data from state DOTs, predict and display state-to-state traffic flows, and compare projected and actual traffic volumes.

5. WINTER MAINTENANCE MANAGEMENT

The winter road maintenance community is well versed in the use of tailored road weather information to take proactive measures to lessen the impacts of snow and ice. However, the need for improvements in the process, particularly with respect to information integration and decision support, was identified through the STWDSR project. Developing, testing, evaluating and ultimately implementing advanced decision support systems has been a focus of the program, with the goal being prototypes that the private sector can use to build road weather services. The MDSS Functional Prototype combines advanced weather prediction capabilities with transportation system information (e.g., road segments, treatment material supplies, crew shifts) to recommend winter maintenance courses of action. Prototype components include weather prediction models, a data fusion and forecast system, a road temperature algorithm, a chemical concentration algorithm, a road mobility algorithm, rules of practice logic, and a graphical display system (NCAR 2002).

Five national laboratories are participating in MDSS prototype efforts, which are funded through the FHWA ITS Joint Project Office. The participating national laboratories include the Army Cold Regions Research and Engineering Laboratory, the National Center for Atmospheric Research, the Massachusetts Institute of Technology Lincoln Laboratory, the NOAA National Severe Storms Laboratory, and the NOAA Forecast Systems Laboratory. The national laboratories released the first functional prototype in October 2002 for demonstration and evaluation. It is hoped that, with technical support from the national laboratories, multiple vendors will embrace the Functional Prototype, develop next generation RWIS products tailored to end user needs, and continually improve upon the prototype system or its components.

6. CONCLUSION

The Road Weather Management program has taken significant steps toward understanding weather effects, enhancing national environmental observing

capabilities, conducting research, and advancing successful techniques. Such efforts will continue as the bridge between transportation and meteorology is strengthened. A dedicated, formal road weather research program with products targeted toward traffic, emergency and maintenance managers would increase the safety, mobility and productivity of the nation's roadways. National security and environmental quality would also benefit from program products.

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