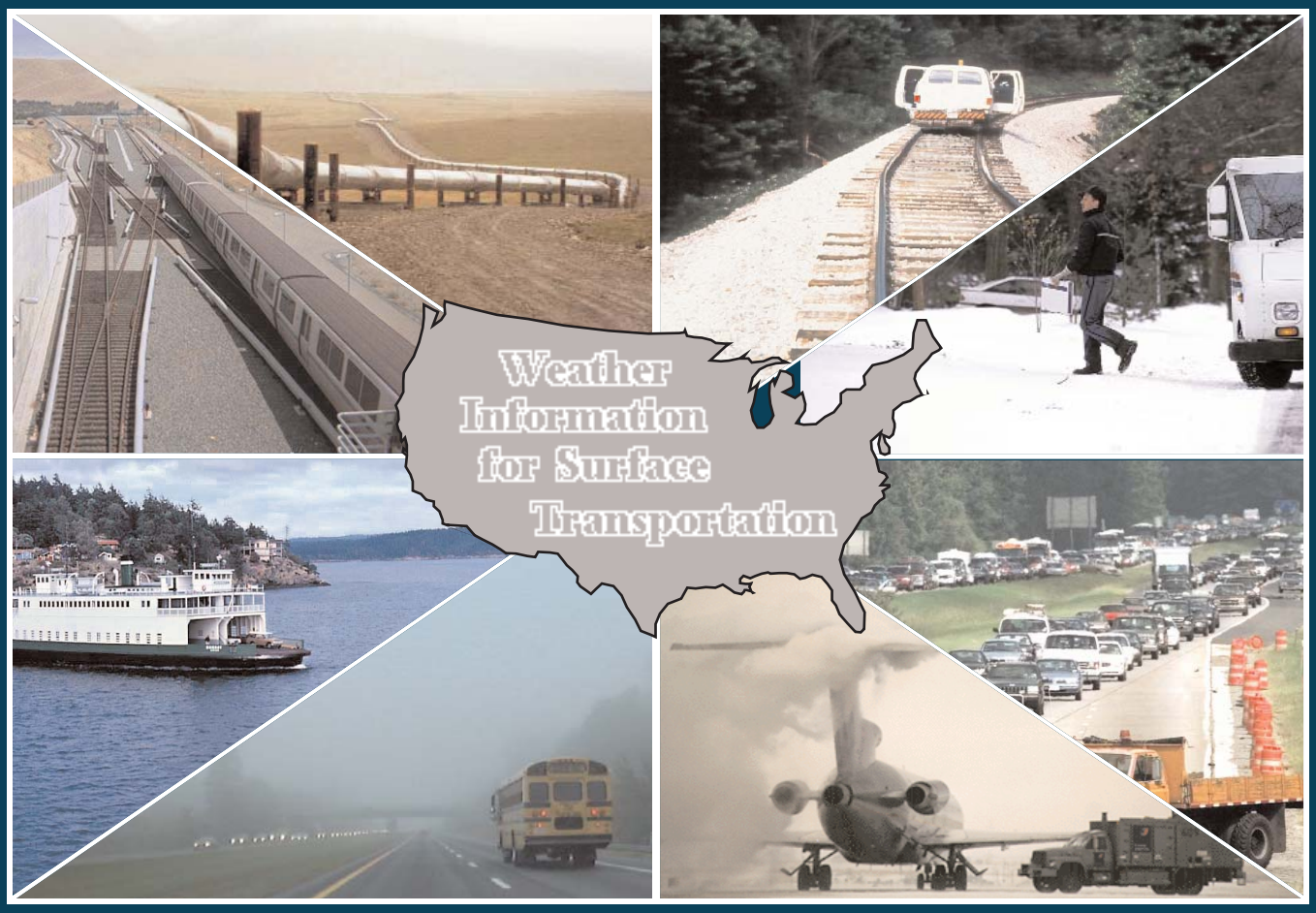
WEATHER INFORMATION FOR SURFACE TRANSPORTATION

Update on Weather Impacts and WIST Results



Office of the Federal Coordinator for
Meteorological Services and Supporting Research

FCM-R26-2006

August 2006

THE FEDERAL COMMITTEE FOR
METEOROLOGICAL SERVICES AND SUPPORTING RESEARCH (FCMSSR)

VADM CONRAD C. LAUTENBACHER, JR., USN (RET.)
Chairman, Department of Commerce

DR. SHARON HAYS (Acting)
Office of Science and Technology Policy

DR. RAYMOND MOTHA
Department of Agriculture

BRIG GEN DAVID L. JOHNSON, USAF (RET.)
Department of Commerce

MR. ALAN SHAFFER
Department of Defense

DR. JERRY ELWOOD
Department of Energy

DR. MAUREEN MCCARTHY
Science and Technology Directorate
Department of Homeland Security

DR. MICHAEL SOUKUP
Department of the Interior

MR. RALPH BRAIBANTI
Department of State

MR. RANDOLPH LYON
Office of Management and Budget

MS. VICTORIA COX
Department of Transportation

MR. DAVID MAURSTAD
Federal Emergency Management Agency
Department of Homeland Security

DR. MARY L. CLEAVE
National Aeronautics and Space Administration

DR. MARGARET S. LEINEN
National Science Foundation

MR. PAUL MISENCIK
National Transportation Safety Board

MR. JAMES WIGGINS
U.S. Nuclear Regulatory Commission

DR. LAWRENCE REITER
Environmental Protection Agency

MR. SAMUEL P. WILLIAMSON
Federal Coordinator

MR. JAMES B. HARRISON, Executive Secretary
Office of the Federal Coordinator for
Meteorological Services and Supporting Research

THE INTERDEPARTMENTAL COMMITTEE FOR
METEOROLOGICAL SERVICES AND SUPPORTING RESEARCH (ICMSSR)

MR. SAMUEL P. WILLIAMSON, Chairman
Federal Coordinator

MR. THOMAS PUTERBAUGH
Department of Agriculture

MR. JOHN E. JONES, JR.
Department of Commerce

RADM FRED BYUS, USN
United States Navy
Department of Defense

BRIG GEN LAWRENCE A. STUTZRIEM, USAF
United States Air Force
Department of Defense

MR. RICKEY PETTY
Department of Energy

MR. WILLIAM RHODES (Acting)
Science and Technology Directorate
Department of Homeland Security

MR. JOHN VIMONT
Department of the Interior

MR. ANTHONY FURST (Acting)
Federal Highway Administration
Department of Transportation

MR. JAMES H. WILLIAMS
Federal Aviation Administration
Department of Transportation

DR. JONATHAN M. BERKSON
United States Coast Guard
Department of Homeland Security

MR. JEFFREY MACLURE
Department of State

DR. S. T. RAO
Environmental Protection Agency

MR. JOHN GAMBEL
Federal Emergency Management Agency
Department of Homeland Security

DR. RAMESH KAKAR
National Aeronautics and Space Administration

DR. JARVIS MOYERS
National Science Foundation

MR. DONALD E. EICK
National Transportation Safety Board

MS. LETA A. BROWN
U.S. Nuclear Regulatory Commission

MS. ANDREA PETRO
Office of Management and Budget

MR. JAMES B. HARRISON, Executive Secretary
Office of the Federal Coordinator for
Meteorological Services and Supporting Research

Preface

Just over 3 years ago, NOAA released its first report on improving surface transportation safety and cost efficiency through improved weather and climate information products. The 2002 WIST Report, *Weather Information for Surface Transportation (WIST)—National Needs Assessment Report*, which provided the roadmap for the Nation's surface weather activities, helped catalyze a rapid expansion of interagency, intergovernmental, and public-private partnering to mitigate the safety and economic risks of "transportation weather." This update focuses on the status of transportation weather issues in the Nation and the results achieved since that first WIST Report. Although data collection and incident monitoring is still limited, the available data do show that progress is beginning. For example:

- On the Nation's roadways, weather-related crash injuries declined by 3.5 percent (21, 023 injuries) in the first 2 years following the release of the WIST Report in 2002. During the same period, vehicle-miles driven increased by 3.7 percent. The 21,023 fewer injuries equate to about $0.5 billion saved in direct and indirect economic consequences. (Note: The National Highway Traffic Administration report for 2005 is due out in October 2006, at which time these statistics will be updated.)
- From 2002 to 2004, weather-related recreational boating accidents decreased from 228, with 66 fatalities, to 178 with 43 fatalities. Since 2002, weather has dropped out of the Coast Guard's "Top Ten Contributing Factors" for recreational accidents.
- Surveys of users of State "511" road information services show that users want and use information on weather conditions affecting their route of travel. Most of these WIST users have altered their route or their travel plans to avoid weather-related hazards or delays. Local television and radio stations now routinely carry combined traffic and weather updates specific to their broadcast area.
- Roadway freight lines are equipping their trucks to receive NOAA Weather Radio anywhere on the Nation's highways. Automobile manufacturers are offering new cars equipped with radios that can receive NOAA Weather Radio.

This update also highlights areas where further steps can be made in the near term. When statewide transportation incident reporting systems are implemented, we will be able to monitor, assess, and manage transportation weather risks, as well as evaluate the benefits of WIST-informed transportation decisions. R&D programs are in progress to improve warnings and decision support systems, implement weather-responsive traffic management in communities, and provide the observational support necessary for location-specific WIST. I am pleased, and proud, that my Office and NOAA have helped to foster and lead these successes, which depend on the combined efforts of many Federal agencies, State and local authorities and transportation departments, the university R&D community, professional organizations, the news media, and our partners in industry who provide or use WIST services and products.

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

Contents

Weather Information for Surface Transportation
Update on Weather Impacts and WIST Results

PURPOSE

This paper highlights the social and economic benefits from increased attention to the weather information needs of those who use, operate, and manage America's surface transportation infrastructure. It updates the information on impacts to that infrastructure from adverse weather, previously documented in the 2002 publication, *Weather Information for Surface Transportation (WIST)—National Needs Assessment Report* (WIST Report) **[1]**. Further actions to increase the social and economic benefits from WIST improvements are identified. Appendices document the growth since 2002 of WIST-related activities in Federal agencies, State and local government, the private sector, and the science community.

BACKGROUND

Strategic Goal No. 1 of the U.S. Department of Commerce is to "provide the information and tools to maximize U.S. competitiveness and enable economic growth for American industry, workers, and consumers" **[2]**. The National Oceanic and Atmospheric Administration (NOAA) reflects this goal in its vision of:

> An informed society that uses a comprehensive understanding of the role of the oceans, coasts, and atmosphere in the global ecosystem to make the best social and economic decisions. **[3]**

Investments in WIST infrastructure that are well planned and implemented provide the information and tools that allow transportation system users, operators, and managers to make better decisions. The benefits of all those better-informed decisions include fewer deaths and injuries from weather-related accidents, improved operational efficiency and capacity in all transportation sectors, and reduced maintenance and repair costs for our Nation's transportation systems. Investments in WIST are investments in safety and security, quality of life, and economic productivity.

In December 2002, the NOAA released the WIST Report, the first comprehensive assessment of how improved weather information could better meet the needs of America's surface transportation users and those who operate and manage surface transportation systems. Appendix A recounts the Federal interagency activities and decisions that led to the WIST Report and the subsequent expansion in interagency, intergovernmental, and public-private partnering that it helped to catalyze. Important as these ongoing activities are to the results attained and the further benefits that lie ahead, the focus of this update is the status of transportation weather issues in the Nation and the results achieved since 2002.

WEATHER IMPACTS AND RESULTS FROM WIST ADVANCES SINCE 2002

The WIST report covered six surface transportation sectors:

- Roadways—State and Federal highways, roads, and streets.
- Long-haul railways—rail lines providing intercity freight and passenger service, with their yards, stations, and depots.
- The National Marine Transportation System—coastal and inland waterways, ports and harbors, and the intermodal terminals serving them.
- Rural and urban transit—bus and van services on streets and roadways, and rail lines for metropolitan subway and surface "light-rail" systems.
- Pipeline systems—Above- and below-ground pipelines for commodities such as crude oil, refined petroleum products, and natural gas, plus the storage, transfer, and pumping facilities for these pipelines.
- Airport ground operations—All ground movement of vehicles, work crews, and passengers.

New data on weather impacts and evidence of improvements from WIST advances in each of these sectors are reported first. After that, four high-priority areas for improving WIST are highlighted: weather impacts on transportation system congestion; travelers' survey responses on the value of timely, location-specific roadway weather information; recent advances in improving user access to WIST before and during travel; and in-vehicle WIST delivery.

Roadway Weather and WIST

- On average, there are over 6,442,000 vehicle crashes each year. More than 24 percent of these crashes (approximately 1,571,500) are weather-related.[1]
- Nearly 7,400 people are killed and over 690,000 people are injured in weather-related crashes each year.
- Data from the National Highway Traffic Safety Administration (NHTSA) show ***that weather-related crash injuries declined by 3.5 percent (21, 023 injuries) in the first 2 years following the release of the WIST Report in 2002.*** During the same period, vehicle miles increased 3.7 percent.
- ***This reduction in injuries equates to about $0.5 billion in reduced economic costs.***[2]

[1] A "weather-related crash" is defined by the FHWA Road Weather Management Program as a crash occurring in the presence of rain, sleet, snow, fog, wet pavement, snowy/slushy pavement, and/or icy pavement. This definition accounts for both atmospheric weather conditions and resultant surface conditions that impact roadway users. Crash data are 10-year averages from 1995 to 2004, from National Highway Traffic Safety Administration (NHTSA) data.

[2] Estimated economic costs are based on a weighted average cost of $23,704 per injury, which is based on applying the distribution of injury severity levels and costs estimated by NHTSA in 2000 for all crashes to the NHTSA weather-related crash data. See reference **[4]**, especially Tables 2 and 3, pg. 9.

- The preliminary 2005 data from NHTSA indicate that the downward trend in weather-related crash injuries from 2002 to 2004 is likely to be continued in 2005. (Note: The NHTSA final report for 2005 is due out in October 2006, at which time these statistics will be updated.)

Railway Weather and WIST

- Annual average weather-related fatalities on railways are much lower than for roadways.
- Between 1995 and 2005, 865 weather-related accidents or incidents occurred on America's railways, causing 8 deaths, 1,242 injuries, and property damage costs of more than $189 million.
- Between 2002 and 2005, property damage attributed to weather-related railway accidents decreased by $1,016,378.
- Most weather-related deaths (62.5 percent) and injuries (91.1 percent) between 1995 and 2005 were associated with accidents or incidents associated with extreme temperature variations.
- The majority of property damage between 1995 and 2005 resulted from extreme high temperatures (30.8 percent), liquid precipitation (22.8 percent), and high wind events (16.9 percent).

Marine Transportation System Weather and WIST

- Between 1996 and 2000, weather-related causes accounted for 11 percent of marine transportation accidents and 3.6 percent of all recreational boating accidents.
- While not all weather-related, the annual totals for marine transportation accidents, fatalities, and property damage all decreased between 2002 and 2004. Fatalities were cut in half (from 62 to 36).
- ***Weather-related recreational boating accidents decreased from 228, including 66 fatalities, in 2002 to 178 (43 fatalities) in 2004.*** Since 2002, weather has dropped below the "Top Ten Contributing Factors" for recreational boating accidents.

Rural and Urban Transit Weather and WIST

- Data on weather-related fatality, injury, and property damage are currently not available from the Federal Transit Administration's Safety and Security Database.
- However, overall safety incidents (accidents, crashes, mishaps) decreased by 9,392 from 2002 to 2004, resulting in a decrease of 32 fatalities and 278 injuries. Some of this decrease may be due to improved use of weather information.

Pipeline Systems Weather and WIST

- Between 2002 and 2005, the pipeline systems sector experienced 4 weather-related fatalities and 14 weather-related injuries, all occurring in 2005. **[5]**
- In 2005, the number of pipeline incidents caused by "natural forces" (defined as heavy rains/floods, high winds, lightning, temperature, earth movement, and various other causes) increased dramatically due to hurricane damage.
- Three of the fatalities were attributed to incidents caused by temperature and one to high winds; all four incidents were in natural gas distribution activities.
- Overall, between 2002 and 2005, natural forces accounted for 8.1 percent of liquid pipeline accidents, 17.4 percent of gas transmission accidents, and 13.6 percent of gas distribution accidents.

Airport Ground Operations Weather and WIST

- National statistics on weather-related fatalities, injuries, and property damage in airport ground operations are not currently available. However, there are ample anecdotal examples of weather's impact on airport ground operations.
- All airport grounds operations (e.g., baggage loading and unloading, refueling, ramp activities, passenger transport to aircraft) cease when ***lightning*** is detected within a certain distance of an airport.
- At SEATAC (Seattle-Tacoma) airport in February 2006, an airport worker was dazed when lightning struck the plane he was loading on the tarmac.
- ***Snow or freezing precipitation*** affects vehicles involved in airport ground operations much as it affects roadway vehicles. When the access ways and tarmac are wet or slippery, travel speeds are decreased, the risk of mishaps increases, and the efficiency of operations decreases.
- ***Strong winds*** affect airport ground operations through increased risk of items being blown into a person, vehicle, or aircraft. Winds also restrict activities of airport construction crews.
- ***Extreme temperatures*** can cause increased times to accomplish normal airport ground operations tasks. Personnel must wear more layers of protective clothing during extremely cold temperatures. During extremely hot temperatures, personnel are allowed time to cool off and rehydrate by drinking liquids.

Weather Impacts on Transportation Congestion

During remarks to the National Retail Federation in May 2006, Secretary of Transportation Norman Y. Mineta called congestion one of the single largest threats to the economy and announced a new national initiative to tackle highway, freight, and aviation congestion. He noted that America loses an estimated $200 billion a year due to freight bottlenecks and delayed deliveries. The Secretary added that consumers lose 3.7

billion hours and 2.3 billion gallons of fuel sitting in traffic jams; airline delays waste $9.4 billion a year.**[6]**

Demand for highway travel by Americans continues to grow as the population increases, particularly in metropolitan areas. Construction of new highway capacity has not kept pace with this growth. Between 1980 and 1999, route miles of highways increased 1.5 percent, while vehicle miles of travel increased 76 percent. This disparity has consequences for safety, quality of life, and transportation costs to freight shipping and travelers. **[7]**

- In May 2006, the Department of Transportation released the *National Strategy to Reduce Congestion on America's Transportation Network*, which ***attributes 15 percent of all transportation system congestion to the adverse weather conditions of snow, ice, and fog.***
- The Texas Transportation Institute (TTI) estimated that, in 2000, the 75 largest metropolitan areas experienced 3.6 billion vehicle-hours of delay, resulting in 21.6 billion liters (5.7 billion gallons) in wasted fuel and $67.5 billion in lost productivity. **[8]**
- Congestion is growing in areas of every size. For all urban population categories, congestion was more severe, lasted a longer period of time each day, and affected more of the transportation network in 1999 than in 1982. The average annual delay per person climbed from 11 hours in 1982 to 36 hours in 1999. Over the same period, delay time quintupled in areas with less than 1 million people. The time to complete a trip during the congested period also continues to increase. (For more details on the study that produced these data, see appendix B.)

Road Travelers Want Timely, Local Weather Information

In July 2000, the Federal Communications Commission designated "511" as the national traveler information telephone number. The first 511 service with weather information included was launched in October 2001. It gave Nebraska travelers statewide 511 access. Early NOAA symposia and the WIST Report greatly influenced the incorporation of weather into State-sponsored 511 Services. ***As of May 2006, 511 services were available in 28 states.***

Surveys of users of "511" services and other regional weather information systems have documented the value that travelers place on the weather information these services provide:

- A survey of users of the Greater Yellowstone Regional Traveler and Weather Information System found that respondents felt that ***winter road conditions and weather forecasts were the most important features on 511***. When asked if they would change their travel plans (on a scale from 1 to 5) if poor conditions were reported on 511, respondents responded that they would be most likely to alter their plans by:

- Changing travel times—mean response was 4.2 (between very likely = 5 and likely = 4) with a standard deviation of 1.11.
- Taking an alternate route—mean response of 3.7 (between likely = 4 and neutral = 3) with a standard deviation of 1.22.
- Canceling the trip—mean response of 3.3 with a standard deviation of 1.47.
- Stopping at a nearby town—mean response of 3.3 with a standard deviation of 1.28.

- A survey of users of SmartRoute Systems Advanced Traveler Information Services for the Florida counties of Miami-Dade, Broward, and Palm Beach found that ***information about weather is important or very important to 66.9 percent of respondents***. When asked if they would change their travel plans if poor conditions were reported on 511, these respondents said they would be most likely to alter their plans by:
  - Changing travel route—41.1 percent agreed strongly and an additional 56.4 percent agreed.
  - Postponing or delaying travel—5.1 percent agreed strongly and an additional 23.6 percent agreed.
  - Choosing a transit system alternative—6.9 percent agreed strongly and an additional 16.9 percent agreed.
- A survey of users of the 511 Virginia service found that respondents think that weather and congestion information is likely to affect their travel. Information on adverse road weather for their initially planned route causes participants to stop or change routes.
  - ***Forty-nine percent of all respondents indicated that they had changed their plans based upon what they had heard on 511 Virginia, and 166 of 212 respondents (or 78 percent) indicated that they had altered their plans by changing their route.***

Improving Access to WIST before and during Travel

Both public and private entities have been exploring new or enhanced means of providing traffic and weather information to roadway users. The following programs and features provide increased access to and awareness of surface transportation weather:

- Television and radio stations have increased their coverage of surface weather conditions that could impact users of the Nation's transportation systems.
- For travelers seeking road weather and traffic information the old-fashioned way—tuning in a local radio station—many stations broadcast a continuous snapshot of traffic conditions and provide frequent reports.
- Reporting current information every 10 minutes—"Weather and traffic on the *N*'s"—has become a popular feature on news-oriented television and radio stations.

- Seven cell phone carriers, including Verizon Wireless and Sprint, offer *Rand McNally Traffic*, which supplies phone users with text messages and maps about traffic conditions in 94 metropolitan areas. This service reports accidents, lane closings, congestion, and the average speed of vehicles on various roads.
- Several cell phone service providers (e.g., Verizon and Clear Channel) are working to increase multimedia content available on cell phones, such as television broadcast information. This service should eventually provide another method by which users of surface transportation systems can access timely weather information for their location and planned routes.
- Some businesses offer free traffic information on the telephone. By dialing Traffic.com's 866-MY-TRAFC (698-7232) number, for example, motorists can receive reports on traffic conditions in 50 metropolitan areas. At the company's Internet website, www.traffic.com, travelers can register for free traffic alerts and set up custom reports for traffic conditions on commonly used roads.
- Intellicast's "Drivecast" and The Weather Channel's "Interstate Forecast" websites help travelers plan their highway trips.
- Websites and webcams are being used to show real-time information on roads that are congested so that travelers can view them before leaving an airport or a hotel.
- Many radio stations, as well as local television stations and some newspapers, have detailed traffic maps that enable Internet users to keep abreast of accidents, road maintenance delays, and other snafus.
- Over 30 State departments of transportation have websites that provide route-specific information on weather and pavement conditions.
- Many State and city websites have links to webcams where viewers can view road conditions and see how fast vehicles are moving on local roads. Internet users can, for example, use the New York City Department of Transportation's website, www.nyctmc.org, to view still or streaming video from 98 traffic cameras in the five boroughs of the city, including 45 cameras in Manhattan.

In-Vehicle WIST Delivery

In the past, the standard medium for travelers to access road weather information while on the road was by radio, either from AM and FM broadcast stations or via citizens band (CB) talk among travelers. New communications technologies and adaptations of existing ones are rapidly expanding the options for timely information that is highly specific to the route an individual traveler is taking or might wish to consider as an option.

- ***NOAA Weather Radio (NWR) broadcasts are now available in cars from several manufacturers (BMW, Mercedes, Range Rover, and Saab).*** Buyers can order a car equipped with a radio capable of receiving the NWR broadcasts.

- ***Freight lines are equipping their truck fleets with radios equipped to receive NWR broadcasts.*** A major nationwide freight line, Schneider National, Inc., and a manufacturer of heavy-duty radio receivers used in the trucking industry have received the Mark Trail NOAA Weather Radio Award from NOAA for their roles in furthering this mode of in-vehicle WIST delivery.
- Car rental companies, Avis and Budget, recently began renting "Where2" global positioning devices at 125 of their rental locations in the United States, Canada, and Puerto Rico. The devices monitor traffic and suggest alternate routes. They can tell drivers every turn to make and what traffic is ahead in about 50 cities. Traffic information is fed into the system by collecting real-time traffic data and predicting vehicular flow.

FURTHER STEPS TO IMPROVE WIST

The concerted efforts to improve WIST through interagency coordination, intergovernmental cooperation, and public-private partnering are beginning to produce results. Many activities are in progress, and more benefits will be flowing from the investments made or planned. However, the job is not finished. Below are some areas where gaps exist or opportunities await.

Data Collection and Analysis to Establish WIST User Needs and Monitor Results

As the updates in the previous section show, some of the data for weather-related impacts in the surface transportation sectors are already showing improvement in several areas, such as reduced crashes on roadways and fewer recreational boating mishaps. However, the information on weather-related transportation incidents and impacts in each transportation sector varies greatly in the detail, accuracy, and comprehensiveness of the data available. In some sectors, either the data are not currently collected or are not collected in a single, centralized database. Understanding the weather impacts and documenting the results of WIST implementations require gathering data from a variety of sources for compilation and analysis.

In a modern information-driven economy, sound fiscal decisions at the Federal, State, business, and individual levels require good economic data. Cost-effective public health practice depends on good medical reporting. Just so, effective planning for and response to the diverse impacts of weather on our surface transportation infrastructure requires sound data, available in timely fashion to decision makers at every level and in every sector.

The transportation reauthorization legislation passed in 2005, titled *Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users* (SAFETEA-LU), includes new requirements for state Departments of Transportation to develop and maintain statewide incident reporting systems. Appendix C describes three parallel and highly important activities, already in progress, that are relevant to implementing these requirements. These activities should be appropriately coordinated and directed toward achieving the overall incident reporting objectives of the legislation. In particular, statewide incident reporting systems should be designed to provide the data

on weather-related incidents needed to monitor road weather risks and assess progress toward reducing and managing them.

Improved Warning and Decision Support

Through both private and public agency weather warning and decision-support efforts, improvements have been made to:

- The ability of State departments of transportation to provide better winter maintenance capabilities, thereby reducing congestion, decreasing operating costs, and limiting the highway safety risks from adverse weather events (e.g., snow, rain, floods, fog).
- Freight company operations by allowing improved routing options to avoid hazardous conditions (e.g., strong winds, freezing precipitation).
- Railroad operations by allowing dispatchers to stop trains to avoid areas of strong winds and potential track flooding or washout.

Appendix C lists some of the projects now in progress that can produce safety and economic benefits by providing more effective and timely weather warnings and decision-support information to WIST users in all transportation sectors.

Weather-Responsive Traffic Management

Weather-responsive traffic management is a systematic approach to planning and implementing traffic management strategies to mitigate the impacts of adverse weather on traffic flow. Typically, such strategies are location specific, requiring local transportation system managers to be able to predict or detect a weather event, assess its severity and impact area, and make timely traffic system management adjustments under suboptimal conditions. Although this challenging field is still in its infancy, appendix C provides some excellent examples illustrating the potential if such strategies were expanded and adapted in communities across the Nation.

Improved Observational Support for WIST Research and Applications

The local and time-sensitive nature of many WIST applications often requires denser observations, spatially and temporally, in the vicinity of affected transportation systems. Successful WIST applications also require near-real-time access to these observational data, capability to integrate them into nowcasting and forecasting systems, and delivery of the results to transportation system managers and users in time to enable effective mitigating responses. Appendix C includes examples of projects and R&D initiatives in progress to meet these observational requirements for improving WIST.

APPENDIX A

The Emergence of WIST as a Major Application for End-to-End Weather Observing and Forecasting

Starting in September 1998, the Federal Committee for Meteorological Services and Supporting Research (FCMSSR) formally recognized the importance of identifying and addressing users' needs for weather information for surface transportation (WIST). The existing and potential WIST users include those who operate and maintain the Nation's surface transportation infrastructure, as well as all those who use that infrastructure to move goods and people from one location to another. The first WIST Symposium, jointly sponsored by NOAA and the Federal Highway Administration (FHWA),[3] was held in December 1999, with a second WIST Symposium in December 2000. These symposia provided major venues through which to: (1) gather information on and discuss weather support capabilities and deficiencies, (2) facilitate interaction among public and private agencies involved in WIST, and (3) validate details on weather information needs throughout the surface transportation sectors.

As a result of the WIST symposia, the Office of the Federal Coordinator for Meteorological Services and Supporting Research (OFCM) in NOAA, working with the FHWA and other agencies and offices with missions to sustain and enhance surface transportation infrastructure, produced the December 2002 report, *Weather Information for Surface Transportation (WIST) - National Needs Assessment Report* (WIST Report). Since its release, the WIST Report has catalyzed interagency coordination and broad constituency support for: (1) developing operational and R&D weather programs designed to improve the safety, mobility, and economic value of the nation's surface transportation systems, and (2) promoting strategies and tools to mitigate the impact of weather on surface transportation. The WIST report was endorsed by the U.S. Department of Transportation (USDOT) Undersecretary for Policy, the Federal Highway Administrator, and the NOAA Administrator. The impact of the WIST report, coupled with NOAA's continued outreach through conferences, workshops, and symposia, has expanded partnerships among Federal, State, local government, academic, and private-sector entities.

Another result of the WIST report and related Federal agency activities has been to stimulate and focus the involvement in WIST issues of many organizations with nationwide constituencies and audiences. Among the key organizational efforts in support of the larger WIST objectives have been the following milestones:

- In 2003, the American Meteorological Society, the foremost meteorological professional society in the United States, hosted a policy forum on "Weather and Highways" to explore how to improve the safety and operations of the nation's highway system through better application of weather information.

[3] The Federal Highway Administration, through its Road Weather Management Program, has long been active in improving weather information for transportation system managers and users. Appendix B provides an update on this program, which is central to WIST R&D and implementation efforts.

- In January 2004, the National Research Council's Committee on Weather Research for Surface Transportation published its report, *Where the Weather Meets the Road—A Research Agenda for Improving Road Weather Services*. The committee's findings and recommendations were formulated to provide a framework to engage the transportation and weather communities, along with other stakeholders, to help shape and guide a focused road weather research program. The recommendations were meant to help the weather and transportation research and operations communities capitalize on existing capabilities and take advantage of opportunities for advances.
- In 2005, the Transportation Research Board of the National Academies formed the Task Force on Surface Transportation Weather to promote research and technology transfer of techniques to better manage surface transportation, minimizing the impacts of weather and maximizing safety and mobility.
- In September 2005, the Weather Information & Applications Special Interest Group (WIA-SIG) of the Intelligent Transportation Society of America (ITS America) published the report, *Transportation Weather Research and Development Needs to Support ITS, Version 0.0.*

Interagency activities since the WIST Symposia and release of the WIST report have strengthened the sharing of information and synergy across agency-funded R&D programs:

- NOAA and the FHWA drafted a Partnering Plan on July 1, 2004, to start the process of increasing collaboration between these two organizations, which play key roles in improving WIST capabilities within their respective areas.
- Some of the many FHWA activities in the Road Weather Management Program are summarized in Appendix B.
- NOAA's Office of Program Analysis and Evaluation used the WIST Report as the foundation for developing NOAA's Surface Weather Program in December 2004.
- In July 2005, NOAA and FHWA signed a Memorandum of Understanding, strengthening the two agencies' working relationships.
- In September 2005, NOAA, through the OFCM, published the *WIST Initiative Document - First Steps to Improve the Nation's WIST Capabilities And Services*. This document represents the early recommendations of the Working Group for Weather Information for Surface Transportation on key actions that should be taken by the responsible agencies in the OFCM Federal coordinating infrastructure to collaborate on and address national surface transportation safety, mobility, and productivity issues.
- NOAA has been pursuing increased WIST capabilities by working to transition NOAA's Meteorological Assimilation Data Ingest System (MADIS) from research to operational status. By providing support for data

assimilation, numerical weather prediction, and other hydrometeorological applications, the planned National Surface Weather Observing System (NSWOS) will make available value-added data for improving regional and mesoscale weather forecasting. The FHWA envisions that its *Clarus* system (see Appendix B) will ultimately become part of NSWOS.

Non-Federal partners in WIST R&D and implementation projects have continued to make substantial contributions, such as the following:

- The State departments of transportation are key partners in developing new WIST capabilities in the area of maintenance decision-support systems. At the international level, they have formed a collaborative effort called "Aurora" for research, development, and deployment in the field of road weather information systems (RWIS), serving the interests and needs of public agencies.
- Private weather service providers have made significant contributions to the Nation's WIST capabilities by providing tailored weather products and services, improved modeling, and increased access to and awareness of WIST.
- The automobile manufacturers are key players in USDOT's Vehicle Infrastructure Integration (VII) Initiative. The vision of this initiative is to have every car manufactured in the United States equipped with a communications device and a Global Positioning System (GPS) unit so that data can be exchanged with a nationwide instrumented roadway system. Realization of this vision could reduce highway fatalities substantially, while offering dramatic improvements in transportation mobility. Weather information has been selected as one of the "first day of operation" products and services to be offered by such a system.
- At least eight universities are engaged in WIST-related R&D activities. At least one university is providing degree courses and programs related to surface transportation weather. (Information received during recent NOAA-sponsored workshops on ongoing WIST-related R&D activities.)
- ITS America believes that Intelligent Transportation Systems (ITS) will take the Nation's transportation network to the next logical level by enhancing safety, reducing traffic congestion, decreasing emergency response time to crashes, decreasing fuel consumption, and lessening the economic burden on our society. The *National Intelligent Transportation Systems Program Plan: A Ten-Year Vision* sees weather as a common threat to the performance of all transportation modes and calls for ways to improve WIST capabilities through the use of improved weather forecasts and the application of ITS to better use available weather information.
- All forms of public information media—television, radio, Internet, and print—have increased the traveling public's awareness of weather's impact on individuals' travel plans.

- Improved weather forecasts and dissemination methods have attracted greater numbers of people, who "tune in" to learn about the expected impact of weather on their travel plans. More frequent roadway weather updates, such as the popular "weather and traffic on the *N's*" (updates every 10 minutes), are providing travelers with timely information on weather impacts affecting their daily and commuter travel. These local and urban-scale reports bring WIST to a finer scale of spatial and temporal detail than that of 3-day and longer forecasts, which influence longer-distance travel plans such as vacations and non-aviation business travel.
- Internet web sites are giving travelers weather information specific to their route of travel. Surveys of State-sponsored "511" services indicate that travelers do in fact modify their travel plans on the basis of this kind of information.
- The addition of travel information kiosks at highway rest stops has also increased traveler awareness of weather and its potential impact on travel plans, as well as providing route options and travel cautions in response to adverse weather conditions.

Congress and the Administration have taken notice of these important and coordinated efforts. The recently enacted Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (SAFETEA-LU) authorizes the Federal surface transportation programs for highways, highway safety, and transit for the 5-year period from 2005 to 2009. SAFETEA-LU also includes funding for a new Road Weather Research and Development Program and increased funding for the University Transportation Centers, which conduct various WIST-related R&D activities.

APPENDIX B

The Federal Highway Administration's Role in WIST

ROAD WEATHER MANAGEMENT PROGRAM

The FHWA, through its Road Weather Management Program, continues to be very active in promoting new WIST capabilities. The FHWA has fostered development and enhancement of the Maintenance Decision Support System (MDSS) for roadway winter maintenance personnel and the Weather Response System (WRS) for highway traffic management personnel.

- Eight states have joined the MDSS Pooled Fund Study, led by the South Dakota Department of Transportation, to develop an enhanced version of MDSS based on the federal prototype. Other State and local departments and agencies are in the process of procuring the MDSS software or have contracted with private vendors for maintenance decision support capabilities.
- The Road Weather Management Program is currently involved in a cooperative agreement with the Missouri Department of Transportation to develop and deploy a WRS for traffic operations and highway maintenance.
- The prototype system displays national, state, and local maps from the NOAA National Digital Forecast Database (NDFD). It allows users to select desired conditions and determine when such conditions are predicted for a specified area.
- The prototype system is currently being evaluated in the Kansas City Traffic Management Center.
- In 2003, the FHWA published *Best Practices for Road Weather Management*. This resource contains 30 case studies of systems in 21 states that improve roadway safety, mobility, and/or productivity. Maintenance, traffic, and emergency managers across the country were interviewed to capture successful and innovative strategies used to mitigate the impacts of fog, high winds, snow, rain, ice, flooding, tornadoes, hurricanes, and avalanches.
- The FHWA has developed a one-day course on Principles and Tools for Road Weather Management, available through the National Highway Institute. This course for transportation agency staff trains them on tools and strategies for avoiding or minimizing the impact of adverse weather conditions.

CLARUS INITIATIVE

The *Clarus* Initiative aims to develop and demonstrate an integrated surface transportation weather observing, forecasting, and data management system. To do so, it is establishing a partnership to create a Nationwide Surface Transportation Weather Observing and Forecasting System. This system will provide information to all transportation managers and users to alleviate the effects of adverse weather (e.g., fatalities, injuries and delays). *Clarus* is jointly managed by the USDOT Intelligent

Transportation System (ITS) Joint Program Office and the FHWA's Road Weather Management Program.

CONGESTION AND TRANSPORTATION WEATHER

In May 2006, U.S. Secretary of Transportation Norman Y. Mineta announced a new national initiative to tackle highway, freight, and aviation congestion. During remarks to the National Retail Federation, Secretary Mineta described congestion as one of the single largest threats to the economy. He noted that America loses an estimated $200 billion a year due to freight bottlenecks and delayed deliveries. The Secretary added that consumers lose 3.7 billion hours and 2.3 billion gallons of fuel sitting in traffic jams and that airline delays waste $9.4 billion a year. "Congestion is not a fact of life," Secretary Mineta said. "We need a new approach and we need it now." Also in May 2006, the USDOT released the *National Strategy to Reduce Congestion on America's Transportation Network*, which shows that weather (snow, ice, and fog) is responsible for 15 percent of all congestion.

Demand for highway travel by Americans continues to grow as the population increases, particularly in metropolitan areas. Construction of new highway capacity has not kept pace with this growth. For example, between 1980 and 1999, route miles of highways increased 1.5 percent while vehicle miles of travel increased 76 percent. The effects of this disparity are captured in a number of measures and perceptions, including visible and consistent roadway congestion, the loss of personal and professional time, environmental degradation, and general traveler frustration—in essence, a reduction in overall mobility and accessibility **[7].** Some statistics are provided below:

- The Texas Transportation Institute (TTI) estimated that, in 2000, the 75 largest metropolitan areas experienced 3.6 billion vehicle-hours of delay, resulting in 21.6 billion liters (5.7 billion gallons) in wasted fuel and $67.5 billion in lost productivity. **[8]**
- Congestion is growing in areas of every size. TTI's 2001 Annual Urban Mobility Report shows more severe congestion that lasts a longer period of time and affects more of the transportation network in 1999 than it did in 1982, for all urban population categories. The average annual delay per person climbed from 11 hours in 1982 to 36 hours in 1999. Over the same period, delays quintupled in areas with less than 1 million people. The time to complete a trip during the congested period also continues to increase. **[9]**
- Another measure of congestion—the travel time index—indicates how much more time it takes to travel during a peak period than at other times of day. This measure, which is based solely on the regular traffic congestion on the roadways, provides a measure of how much of the change in traffic congestion is due solely to more cars using the roadways. During the past decade, the travel time index on Interstates increased by about 12 percent. This statistic provides information about drivers' experiences as well as the level of congestion on the road because it accounts for delays due to the traffic demand on the road and due to roadway incidents (e.g., crashes, weather induced delays). **[10]**

APPENDIX C
Promising Directions in WIST

DATA COLLECTION AND ANALYSIS

SAFETEA-LU (transportation reauthorization legislation passed in 2005) includes new requirements for State Departments of Transportation to develop and maintain *statewide incident reporting systems*. However, there is currently no guidance or common understanding of what qualifies as a statewide incident reporting system or what is required to develop or maintain such a system. Three parallel and highly important activities relevant to these SAFETEA-LU requirements are in progress.

1. The American Association of State Highway and Transportation Officials (AASHTO) Subcommittee on Systems Operations and Management has prepared a Statewide Incident Reporting Systems Proposed Research Problem Statement (NCHRP 20-7) to address the need for a common incident reporting system. The purpose of the proposed project is to lay the groundwork for an AASHTO business and technology plan to meet the SAFETEA-LU requirements collaboratively. AASHTO would conduct background research and convene a workshop to frame and explore the following questions:

    - What systems and capabilities exist to detect incidents on the National Highway System, where are there geographic and technological gaps, and what are emerging alternatives to address gaps and evolve national incident detection coverage?
    - What initiatives have been taken to fuse NHS incident data across multiple states or nationally, and what public and private sector efforts are investigating alternatives for NHS incident data fusion nationally?
    - Is a single or virtual national traffic operations center or NHS incident reporting center needed, what capabilities should it provide, and what activities are underway to evaluate or plan for such a center?

2. In April 2006, the Transportation Research Board released Transportation Research Circular E-C094, Safety Data Analysis and Evaluation: Research Problem Statements. This document contains research problem statements produced by members and friends of TRB's Safety Data, Research, and Analysis Committee (ANB20), which addresses methods of gathering, storing, and using the transportation safety data for informed decision making. The 12 problem statements contained in Circular E-C094 cover a broad range of highway safety information issues in the areas of safety data improvement, evaluation, and methodology.

3. The FHWA has released a Request for Information (RFI) about a Real-Time System Management Information Program. This program would provide capabilities to monitor, in realtime, the traffic and travel conditions of the major highways of the United States and to share that information with transportation system managers, operators, and users. The program goals are to improve surface transportation system

security, address congestion, improve response to weather events and surface transportation incidents, and facilitate national and regional highway traveler information. Specifically, the program would:

- Establish, in all States, a system of basic real-time information for managing and operation the surface transportation system.
- Identify longer range real-time highway and transit monitoring needs and develop plans and strategies for meeting the needs.
- Provide the capability and means to share the data with State and local governments and the traveling public.

Within 2 years of the date of enactment of SAFETEA-LU, the Secretary of Transportation is to establish data exchange formats to ensure that the data provided by highway and transit monitoring systems, including statewide incident reporting systems, can be readily exchanged to facilitate nationwide availability of information.

As States and local governments develop or update regional intelligent transportation system architectures as described in 23 CFR 940.9, they shall explicitly address real-time highway and transit information needs and the systems needed to meet those needs. States shall also incorporate the data exchange formats established by the Secretary. The term "statewide incident reporting system" is defined as a statewide system for facilitating the real-time electronic reporting of surface transportation incidents to a central location for use in monitoring the event, providing accurate traveler information, and responding to the incident as appropriate.

IMPROVED WARNING AND DECISION SUPPORT

The Joint Action Group for WIST, an interagency working group that reports to the FCMSSR, is compiling information on WIST-related R&D projects and programs across the participating agencies and partners. The three projects described below illustrate the cooperative efforts underway to complete the end-to-end pathways from regional and urban-scale weather observations, nowcasting, and forecasting to WIST users.

Program: Traffic Management Center (TMC) Integration.
WIST R&D Areas: Improved Decision Support Systems.

This project aims to better understand weather information integration in TMC operations and decision making. The project will document a baseline condition that defines the current state-of-the-practice, and develop future concepts and methods that could be implemented to enhance use of weather information in TMCs. Extensive data were collected from 38 TMCs to form an understanding of approaches to weather information integration. The project has just completed the baseline condition documentation and will begin to develop future concepts soon.

Program: Weather Response System (WRS) Prototype.
WIST R&D Areas: Improved Decision Support Systems.

The FHWA is working with the Missouri Department of Transportation to prototype and test a Weather Response System that will bring NWS forecast products into TMCs to assist managers with planning. The prototype will be used to conduct an assessment in order to identify the most important requirements of an enhanced WRS that may be used for operations.

Program: Development of a Roadway Weather Severity Index.
WIST R&D Area: Improved Decision Support Systems.

The Western Transportation Institute (Montana State University) is under taking research to develop a weather severity index that would be appropriate for roadways. The objectives of the index are to correlate with winter maintenance costs, correlate with the relative hazards of weather-related driving conditions experienced by motorists, use data that is already available, and be easy to use and interpret. Because of the significant variability in weather across years during the same season, it is difficult to quantify the effect that weather may have, positively or negatively, on highway operations. It is also difficult to "correct" for the effects of weather when identifying the advantages or disadvantages of various operational and safety improvements. A weather index for roadways would help in such situations. The purpose of this study is to research and develop a weather severity index that would be appropriate for roadways. The desired attributes of the index are as follows;

a. The index would directly correlate with winter maintenance costs. For example, a 10 percent increase in the index value might equate to a 10 percent increase in maintenance costs.
b. The index would correlate with the relative hazards of driving conditions experienced by motorists, including snow, blowing snow, ice, frost, rain, fog and wind. This correlation could be shown by the relative accident frequencies on the same segment of roadway during years of significantly differing weather conditions.
c. The index would use data that is already available, such as through the National Weather Service (NWS) or RWIS stations.
d. The index would be easy to use and interpret.

WEATHER-RESPONSIVE TRAFFIC MANAGEMENT

To ensure roadway safety and minimize congestion, traffic managers can implement a number of strategies, such as operating traffic signals on arterial routes, controlling traffic flow on freeways, detecting and managing incidents, and disseminating traveler information. Weather events and their impacts can be viewed as predictable, nonrecurring incidents that contribute to congestion by reducing capacity--the maximum flow rate at which vehicles can traverse a roadway over a given time period. Every day, weather affects traffic on every road in the Nation by altering pavement conditions, vehicle performance, and driver behavior. Consequently, there is a need for a systematic

approach to the significant challenge of managing traffic during inclement weather. With this in mind, weather-responsive traffic management strategies can be planned and implemented to mitigate weather effects on traffic flow. As with any incident, managers must be able to predict or detect a weather event, assess the nature of the event (e.g., severity, impact area), and manage traffic under less-than-optimal conditions. To prevent weather-related congestion and lessen the impact of unavoidable congestion, traffic managers need to understand how weather impacts roads and traffic, as well as the benefits of weather-responsive strategies. In spite of the ability to prepare for and manage such incidents, the field of weather-responsive traffic management is in its infancy. **[11]**

However, there are a few documented cases where weather-responsive traffic management is being used to reduce weather-related congestion.

- **Weather-Related Signal Timing.** The city of Clearwater, Florida, operates a computerized traffic control system with 145 signals. City traffic managers have developed a unique rain preemption feature that modifies signal timing during rain events to clear traffic from Clearwater Beach, which is a prime destination for tourists visiting Orlando and Tampa Bay. Thunderstorms typically occur in the afternoon, causing significant sudden increases in traffic exiting the beach via the Memorial Causeway (State Route 60).
- **South Carolina Hurricane Evacuation Operations.** In September 1999, roughly three million people were evacuated from coastal areas in Florida, Georgia, North Carolina, and South Carolina prior to landfall of Hurricane Floyd. Over 500,000 South Carolinians evacuated from six coastal counties. Because managers with the South Carolina Department of Transportation (DOT) and the South Carolina Department of Public Safety had not agreed on a lane reversal plan prior to Hurricane Floyd, contraflow (i.e., lane reversal) was not employed during the evacuation. Consequently, there was severe congestion on Interstate 26 between Charleston and Columbia. Traffic and emergency managers quickly developed a contraflow plan for reentry operations after the hurricane. As a result of contraflow, the maximum volume during reentry was 2,082 vehicles per hour per lane—a 44 percent increase over evacuation volumes.
- **Minnesota DOT Access Control.** Since 1996, several Minnesota DOT maintenance districts have worked with the Minnesota State Patrol and county sheriffs to direct traffic off freeways and restrict freeway access at ramps when winter storms create unsafe travel conditions. After maintenance vehicles have cleared snow and ice, the freeways are reopened to traffic. This strategy not only increases safety but also reduces the time required by maintenance crews to clear the roads, decreasing overall weather-related congestion and travel times.
- **Utah DOT Fog Dispersal Operations.** In northern Utah, widespread super-cooled fog (i.e., fog at temperatures less than 32º F) can persist in mountain valleys for weeks. Utah DOT maintenance personnel use liquid carbon dioxide to disperse fog and improve visibility along segments of Interstates 15, 70, 80, and 84; U.S. Highways 40, 89, and 91; and secondary roads in

Cache Valley and Bear Lake Valley. To prevent moisture from freezing on the pavement, this treatment strategy includes application of anti-icing chemicals as the fog is dispersed. This effort provides both safety and mobility benefits.

IMPROVED OBSERVATIONAL SUPPORT

Several programs have resulted, or will result, in improved weather observational support for transportation operations.

- **Washington State Ferries (WSF).** The WSF, in cooperation with the University of Washington Department of Atmospheric Sciences, has formed a project to provide weather information to the general public, users of the Washington State Ferries, recreational boaters, and other marine interests with up-to-date information on weather conditions over the inland waters of Western Washington.
- ***Clarus*:** This FHWA initiative aims to develop and demonstrate an integrated surface transportation weather observing, forecasting, and data management system. It will consolidate information from environmental sensor stations deployed by State DOTs.
- **MADIS.** NOAA is pursuing the transition of NOAA's Meteorological Assimilation Data Ingest System (MADIS) from research to operational status as a part of the National Surface Weather Observation System (NSWOS). When complete, NSWOS will provide weather data relevant to surface transportation to government agencies (including emergency services and law enforcement agencies), the private sector, the academic and research communities, and the general public. NSWOS will ingest meteorological and pavement variables from state DOTs, as part of its hourly ingest of a large number of mesonet observations from across the country. It will distribute quality-controlled information and observations to Federal, State, academic, and commercial organizations. NSWOS will ingest mesonet observations (in any format), combine the observations from different mesonet data providers, quality control the data, and integrate them with other NOAA datasets by converting the observations to standard observation units, time stamps, and formats.

APPENDIX D
References

1. *Weather Information for Surface Transportation (WIST)—National Needs Assessment Report.* Report No. FCM-R18-2002. Office of the Federal Coordinator for Meteorological Services and Supporting Research, National Oceanic and Atmospheric Administration, U.S. Department of Commerce, Washington, D.C. 2002. http://www.ofcm.gov/wist_report/wist-report.htm

2 *Strategic Plan: FY 2004–FY2009. American Jobs, American Values.* U.S. Department of Commerce, Washington, DC. http://www.osec.doc.gov/bmi/budget/Strategic04-1002.htm

3. *Understanding Global Ecosystems to Support Informed Decision-Making. A 20-Year Research Vision.* National Oceanic and Atmospheric Administration, U.S. Department of Commerce, Washington, D.C. 2005. http://nrc.noaa.gov/Docs/Final_20-Year_Research_Vision.pdf

4. *The Economic Impact of Motor Vehicle Crashes 2000*, National Highway Traffic Safety Administration, May 2002.

5. "PHMSA Pipeline Safety Program: National Safety Statistics Report." Pipeline and Hazardous Materials Safety Administration, U.S. Department of Transportation, Washington, D.C. Found at: http://primis.phmsa.dot.gov/comm/StatePages/htmGen/US_SSRep.html.

6. "U.S. Transportation Secretary Mineta Launches New National Initiative to Tackle Highway, Freight, and Aviation Congestion." U.S. Department of Transportation press release DOT 57-06, May 16, 2006. Found at http://www.dot.gov/affairs/dot5706.htm.

7. *Freeway Management and Operations Handbook*, FHWA-OP-04-003. Federal Highway Administration, U.S. Department of Transportation, Washington, D.C. September 2003. Found at http://ops.fhwa.dot.gov/freewaymgmt/freeway_mgmt_handbook/fmoh_complete_all.pdf.

8. *National ITS Architecture*, Documentation – Version 4.0, April 2002.

9. M.E. Hallenbeck, T. Lomax, S. Turner, D.B. Boon, and R. Margiotta. *Traffic Congestion and Travel Reliability—How Bad is the Situation and What is Being Done About It?* Washington State Transportation Center and Texas Transportation Institute. September 2001.

10. Testimony Before the Subcommittee on Highways and Transit, Committee on Transportation and Infrastructure, House of Representatives; United States General Accounting Office; *HIGHWAY INFRASTRUCTURE - Physical Conditions of the Interstate Highway System Have Improved, but Congestion and Other Pressures Continue*; Statement of Katherine Siggerud, Acting Director, Physical Infrastructure Issues.

11. P. Pisano and L. Goodwin. Research needs for weather-responsive traffic management. Paper presented at the Transportation Research Board (TRB) 2004 Annual Meeting. PDF version available at http://ops.fhwa.dot.gov/weather/best_practices/WxRspTfcMgmtTRB2004.pdf.

Office of the Federal Coordinator
for Meteorological Services and Supporting Research

8455 Colesville Road
Suite 1500
Silver Spring, Maryland 20910

301-427-2002

www.ofcm.gov