WEATHER INFORMATION FOR SURFACE TRANSPORTATION (WIST) INITIATIVE DOCUMENT

FIRST STEPS TO IMPROVE THE NATION'S WIST CAPABILITIES AND SERVICES

Committee for Environmental Services, Operations, and Research Needs
(CESORN)

Working Group for Weather Information for Surface Transportation
(WG/WIST)

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Executive Summary

Since 1998, the Federal Committee for Meteorological Services and Supporting Research (FCMSSR) has made weather services and research and development (R&D) activities supporting the surface transportation community a priority for the Federal meteorological community (see Appendix C for complete details). In December 2002, the Office of the Federal Coordinator for Meteorological Services and Supporting Research (OFCM) published the comprehensive report, *Weather Information for Surface Transportation - National Needs Assessment Report*. This publication provides the first-ever compilation and analysis of weather support needs across six surface transportation sectors: roadway, railway, transit, marine transportation, pipeline systems, and airport ground operations. The report also made a number of recommendations for future work regarding weather information for surface transportation (WIST) R&D needs. Both the Interdepartmental Committee for Meteorological Services and Supporting Research (ICMSSR) and the FCMSSR endorsed the recommendations to: identify gaps in coverage of WIST user needs; expand coordination among WIST R&D program managers and WIST providers; translate research results and new technologies into WIST applications; provide the fundamental knowledge to support future technology development and application; and expand WIST-related outreach and education. In August 2004, acting on guidance from the ICMSSR, the OFCM established the Working Group for Weather Information for Surface Transportation (WG/WIST) to develop both a *WIST R&D Plan* and a *WIST Implementation Plan*. The ICMSSR guidance to the WG/WIST was to ensure that all weather support needs across the six surface transportation sectors were considered during the development of the R&D and Implementation Plans.

This W*eather Information for Surface Transportation (WIST) Initiative Document- First Steps to Improve the Nation's WIST Capabilities and Services,* represents the early recommendations of the WG/WIST members on key actions that should be taken by the responsible agencies in the OFCM Federal coordinating infrastructure to collaborate and address national surface transportation safety, mobility, and productivity issues. The WG/WIST has identified three deficiencies and four coordination initiatives that will address these issues.

Deficiency 1. Reliable, coordinated methods to access all observation data appropriate for transportation system-related decision making are lacking.

WIST Coordination Initiative: *Integration of Observation Data*. Integrate data from roadside environmental sensor stations, satellite sensors, weather radars, and vehicle-based sensors into a National Surface Weather Observing System (NSWOS). Component activities to be coordinated:

a. Integrate existing Road Weather Information System Environmental Sensor Stations (RWIS-ESS) into the National Surface Weather Observing System (NSWOS)
b. Link the FHWA's surface transportation weather observation data management system with NSWOS (Clarus Initiative)
c. Demonstrate the concept of the use of vehicle-based road condition probes (Vehicle Infrastructure Integration Initiative)
d. Integrate satellite-based sensor data into surface weather support systems

e. Demonstrate the concept of collaborative adaptive sensing of the atmosphere (Weather Radar Observations)
f. Integrate precipitable water vapor from the Nationwide Differential Global Positioning System Program

Deficiency 2. Lack of implementation awareness: End users need a much better understanding of how to use information on current and forecast weather-related conditions provided to them.

WIST Coordination Initiative: *Transportation Weather Decision Support Systems*. Component program to be coordinated:
a. Winter Weather, Winter Maintenance, and Airport Ground Operations Initiative

WIST Coordination Initiative: *Improved Training for Transportation Weather Applications.* Component programs to be coordinated:
a. Training for transportation operations on making the most of NWS products and services
b. Training for NWS field staff on needs of transportation decision makers
c. Training for transportation operations on a prototype database for surface transportation

Deficiency 3. Current forecast models do not adequately represent surface-level weather phenomena, dynamics, and interactions critical to assessing the impact of weather conditions on surface transportation modes at appropriate spatial and temporal scales.

WIST Coordination Initiative: *Surface Weather Modeling and Simulation*. Component program to be coordinated:
a. Statistical Guidance Initiative for improved prediction of precipitation

There is a compelling case for coordinated action to be taken to minimize the impact weather has on surface transportation activities. For surface transportation, the unintended consequences of incidents, accidents, and crashes in the presence of some form of adverse weather (e.g., rain, snow, sleet, fog, wet pavement, snowy pavement, slushy pavement or icy pavement), include fatalities, injuries, property damage, lost productivity, reduced capacity, and delays. In 2002, in the roadway sector alone, over 23 percent of all vehicle crashes on U.S. highways were weather-related. Specifically, more than 1,451,000 crashes occurred in the presence of some form of adverse weather. Over 7,200 people were killed and more than 588,000 people were injured in these weather-related crashes.

Courtesy of Blaine K. Tsugawa, OFCM staff.

Weather-related crashes are defined as those crashes that occur in adverse weather or on slick pavement or tracks. Weather acts through visibility impairments, precipitation, high winds, and temperature extremes to affect operator capabilities, vehicle (e.g., car, truck, bus, boat, train, subway) performance (i.e., traction, stability and maneuverability), pavement or track friction, roadway or railway infrastructure, and crash risk.

In 2002, over 1,451,000 weather-related roadway crashes occurred. Meanwhile, in 2001, for all aviation regulatory categories taken together, the number of weather-related accidents was 308, and the three-year average (1999–2001) was 367.

WHY THIS INITIATIVE?

For surface transportation, the unintended consequences of weather-related incidents, accidents, and crashes include fatalities, injuries, property damage, lost productivity, reduced capacity, and delays. This *Weather Information for Surface Transportation (WIST) Initiative Document- First Steps to Improve the Nation's WIST Capabilities and Services*, represents the early recommendations of the WG/WIST members on key actions that should be taken by the responsible agencies in the OFCM Federal coordinating infrastructure to collaborate in addressing national surface transportation safety, mobility, and productivity issues. The recommended actions are analogous to actions taken to address aviation weather safety issues. For several decades, public and private investment in aviation weather infrastructure, services, and research has lowered the risks of flying in both visual and instrument meteorological conditions. Both the National Weather Service, through its Aviation Weather Center, and the Federal Aviation Administration (FAA) expend large amounts of money on observation sensors, weather surveillance radar, aviation weather models, forecast products, graphical displays, control facilities, and communications gateways. Through its Aviation Weather Research Program (see Appendix D), the FAA also funds basic and applied research on in-flight icing, turbulence, wake vortices, and other atmospheric phenomena of relevance to the air transportation sector. The WG/WIST recommends a similar coordinated, multiagency approach for surface transportation.

Transportation is recognized as a major crosscutting area affected by and affecting urban weather. The transportation system is at the heart of urban and regional evacuation plans. Transportation is essential to urban commerce, ensuring the timely delivery of manufactured goods, raw materials, and foodstuffs to producers and consumers. Public and private transportation vehicles and networks provide the principal means of passenger movements to work. Taking the perspective of transportation as a factor that influences urban weather, emissions from transportation vehicles are a major contributor to urban air quality problems. Certain types of atmospheric conditions can exacerbate these effects and pose public health risks to certain segments of urban populations.

Railcars and trucks transport significant quantities of hazardous materials (e.g., toxic if inhaled) within urban zones. Any accidental or intentional release of substances may lead to a plume and dispersion of the material. In addition to the quantity of hazardous material released, the initial and subsequent meteorological conditions are major factors in the amount of resulting human exposure and the potential for fatalities and injuries. Simulations and models help to generate dynamic data and provide monitoring and advice on complex events. Plume progression can be modeled from inputs that include weather observation and forecast data, fixed topography and building data, and chemical characteristics.

Urban transportation systems are vulnerable to weather that causes poor visibility, reduces traction and control, or obstructs transportation routes. Impaired visibility may result from coastal and ground fog, smoke, smog, dust, precipitation-induced road spray, and solar glare. Dense fog may form overnight in low-lying areas on highways resulting in a sudden drop in visibility and increased risks of collisions between motor vehicles and roadside structures. Similar conditions may arise during the winter months when warm, moist air moves over existing snow cover. Many urban zones are also located in coastal areas, where onshore winds may occasionally produce very dense fog patches over coastal roadways, lowering visibility to near zero in many cases.

Fog shrouds wrecked cars in the aftermath of a pileup on May 22, 2003, on Interstate 68 in western Maryland. Scores of vehicles were involved in a series of crashes that stretched for 20 miles.

Conditions that reduce traction and control (e.g., rain, snow, ice, hail) produce additional transportation hazards in urban zones. Transportation infrastructures contain numerous bridges and ramps that connect and provide access to principal arterials. Surface temperatures on these structures cool more rapidly than the surrounding roadbeds, often producing hazardous local icing conditions. Track switches and overhead catenaries may freeze on transit and intercity rail systems, ferryboats may have to suspend operations as conditions deteriorate, and airports may curtail or shut down operations altogether. In the case of airports, a ripple effect may occur throughout the United States if a facility affected by heavy rain or frozen precipitation is an important transportation hub. Other wintertime, ground-based icing phenomena of concern include freezing rain or light precipitation present in a rapidly moving cold front that quickly freezes and glazes roads as temperatures fall sharply over a short period of time. In northernmost coastal cities, other short-lived phenomena such as arctic sea smoke and freezing sea spray from high winds may also impair parts of the transportation system.

Preliminary statistics for weather-related crashes over an 8-year period (1995-2002) show that on average there were over 1,570,000 weather-related crashes each year or 24 percent of all vehicle crashes. The number of people killed in weather-related crashes each year was over 7,300 or 17 percent of all crash fatalities. The number of people injured in weather-related crashes each year was over 713,000 or 22 percent of all crash injuries.

PROBLEM:

Why Should We be Concerned?

(See Appendix B for complete details.)

The nation's surface transportation systems touch our lives many times each day. They connect consumers with resources and enable us to travel where we need or desire to go. Nearly every citizen uses or relies on these systems daily—including the 3.9 million miles of public roads, 2.1 million miles of oil and natural gas pipelines, 122,000 miles of major railroads, and over 26,000 miles of commercially navigable waterways. Transportation services were provided at nearly 5,300 public-use airports and over 14,000 private-use airports in 2004, throughout the over 6,800 miles of commuter rail in 2003, and at 321 ports on the coasts, Great Lakes, and inland waterways and over 9,400 commercial waterway facilities in 2002--waterway facilities as counted by the U.S. Army Corps of Engineers are piers, wharves, and docks. Not included are those facilities used exclusively for recreational or active military craft and generally those providing non-maritime use. The total value of the national transportation infrastructure in 2003 was about $1.2 trillion, and 10.5 percent of the gross domestic product (GDP), or about $8 trillion, was related to transportation. Weather influences virtually every type of operation or activity involved in these transportation systems and facilities.

Examples of Weather Impacts on Surface Transportation Safety

a. For the roadway sector, *preliminary* statistics for weather-related crashes over an 8 year period (1995-2002) show that on average there were over 1,570,000 weather-related crashes each year, or 24 percent of all vehicle crashes. The number of people killed in weather-related crashes each year was over 7,300, or 17 percent of all crash fatalities. The number of people injured in weather-related crashes each year was over 713,000, or 22 percent of all crash injuries. A recent example of roadway weather-related crash occurred in Elko, NV, in August 2005. At least four people were killed and a dozen or more were injured when 18 vehicles, their drivers blinded by swirling dust and ash, collided on Interstate 80, west of Elko. The poor visibility was caused by high winds that picked up dust and ash from land near the freeway that had burned about three weeks before.

b. In the marine transportation sector, the Coast Guard attributes 7 percent of recreational boating accidents to weather. An example of a weather-related fatal mishap, involving a scheduled commercial service, occurred in March 2004 when 25 water taxi passengers were thrown into the frigid waters of Baltimore's Inner Harbor. The tragedy claimed the lives of five passengers, including a 6-year-old boy. The 36-foot seaport water taxi capsized in a sudden thunderstorm in which wind gusts reached 55 mph. The water taxi capsized 100 yards offshore from historic Fort McHenry in 44-degree water.

c. In the railway sector, there were 309 accidents in 2001, resulting in over $46 million in damages, 3 deaths, and 75 injuries. An example of a railway sector weather-related mishap illustrates how weather conditions can cause problems specific to a transportation system's infrastructure, and operations. July 29, 2002, was an excessively hot day in the Mid-Atlantic region. As the Capitol Limited sped through Kensington, Maryland, the engineer applied the train's emergency brakes after spotting an area of misshapen track ahead. The multiple car derailment 45 seconds later left bleeding passengers crawling out the windows of overturned cars. A total of 101 passengers were injured, with one still in serious condition the next day. Experts considered the most likely cause of the 30-inch misalignment of the welded track to be buckling due to the hot weather.

Results of the derailment of the Capital Limited

d. In the pipeline sector, weather-related mishaps can occur to both the pipeline and support equipment or aircraft. For example, in October 1994, a major flood on the San Jacinto River near Houston, TX, undermined numerous pipelines. Eight pipelines ruptured, igniting petroleum spills into the river. More than 500 people suffered burn injuries. Effects of weather phenomena are the second-most frequent contributor to pipeline damage or failure. Additionally, on February 22, 2003, a passenger on a single-engine helicopter received fatal injuries during a hot refueling operation. The helicopter had landed at the oil platform for an intermediate fuel stop en route to a West Cameron platform. During the refueling operation, a wind gust started to push the helicopter about the platform. After the helicopter came to rest, the pilot noticed that the main rotor blades had struck a passenger. The NTSB cited failure to maintain directional control of the aircraft during the hot refueling operation as the probable cause, with high winds contributing to the accident.

Examples of Weather Impacts on Surface Transportation Mobility

a. In the roadway sector, capacity reductions can be caused by lane submersion due to flooding and by lane obstruction due to snow accumulation and wind-blown debris. Road closures and access restrictions due to hazardous conditions (e.g., large trucks in high winds) also decrease roadway capacity. On signalized arterial routes, speed reductions can range from 10 to 25 percent on wet pavement and from 30 to 40 percent with snowy or slushy pavement. Arterial traffic volumes can decrease by 6 to 30 percent depending on road weather conditions and time of day. It has been estimated that 23 percent of the non-recurrent delay on highways across the nation is due to snow, ice, and fog. This amounts to an estimated 544 million vehicle-hours of delay per year.

The estimated cost of weather-related delay to trucking companies ranges from $2.2 billion to $3.5 billion annually. Picture copyright AP Wide World Photos.

b. In the railway sector, delays and slow downs occur when steel rails slowly expand and contract as temperatures rise and fall. Under extreme heat, the rail expands and a "sun kink" results. A sun kink causes the track to shift laterally causing a curve in what is otherwise a straight pair of rails. Passenger and commuter trains typically travel at speeds between 69 and 125 miles per hour, but during heat restrictions passenger trains must travel 20 mph lower than the speed limit resulting in increased travel times.

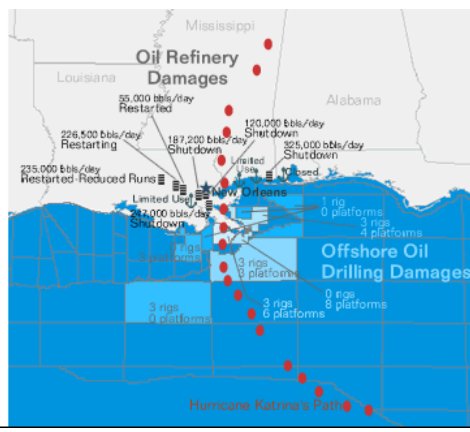
c. Generally, risks from exposure to adverse weather conditions are increasing in other ways as well. Certain elements of the population, such as those who are elderly, disabled, or have a low income, are more severely affected by weather impacts on their modes of transportation than the average citizen may be. Many of the elderly rely on rural and urban transit systems, which are subject to delays and cancellations in adverse weather. The routine of scheduled, accessible transit operations is a key factor in enabling people with disabilities to find and accept employment and to participate in other daily life activities. Because the number of people with disabilities is likely to increase as the population ages, the total risk from adverse weather impacts on their modes of transportation will increase.

Weather Impacts on Productivity

a. In the roadway sector, adverse weather can increase operating and maintenance costs of winter road maintenance agencies, traffic management agencies, emergency management agencies, transit operators, law enforcement agencies, and commercial vehicle operators (CVO). Meanwhile, winter road maintenance accounts for roughly one-quarter of state DOT maintenance budgets, with state and local agencies spending more than $2.3 billion a year on snow and ice control operations, and over $5 billion to repair infrastructure damage caused by snow and ice. Additionally, each year trucking companies and other CVOs lose an estimated 32.6 billion vehicle hours due to weather-related congestion in 281 of the nation's metropolitan areas. The estimated cost of weather-related delay to trucking companies ranges from $2.2 billion to $3.5 billion annually.

b. The marine transportation sector offers a telling illustration of how these essential transportation systems can be affected by weather. On February 27, 2001, fog closed the Houston ship channel to inbound traffic, causing long delays for vessels using this waterway. Similar conditions caused a backlog of almost 80 ships earlier in the month. Additionally, Houston and neighboring ports are home to the nation's largest oil and petrochemical plants. Fog along the Gulf Coast was cited as the main reason for a huge, 12 billion barrel decline in the output of U.S. refineries that week.

c. In the pipeline sector, adverse weather can impact production in various ways. As Hurricane Katrina approached the Gulf Coast at the end of August 2005, 90 percent of the oil platforms operating there were shut down. After the hurricane passed, 20 rigs were missing. Several overland pipelines that send fuel from Gulf Coast refineries to the Midwest and Northeast were out of action after the storm. Hurricane Ivan in 2004 damaged several pipelines that bring the crude oil ashore, and damages to underwater pipelines from Katrina are still being tallied. In March 2005, a weather-related landslide ruptured a high-pressure, 14-inch oil pipeline, causing about 3,000 barrels of crude to flow into a lake in California. The spill was caused by a landslide after rain.



More than 91 percent of oil production and 83 percent of gas production in the Gulf of Mexico region were shut down because of damage to rigs and refineries caused by the hurricane. The impact of these hurricane-related shut downs is felt indirectly in all the surface transportation sectors that use petroleum-derived fuels, as well as the direct impacts on the pipeline sector. Map courtesy of iMapData Inc.

VISION AND GOALS

The WG/WIST has established the following initial vision and set of goals for the WIST R&D Plan:

Vision: Safe and efficient movement of people and goods on the surface transportation system, whatever the weather.

Goals:

1. Timely, accurate, relevant, and accessible observed and predicted information on weather and resulting surface conditions that will support decisions that contribute to:
   - A reduction in weather-related surface transportation deaths, injuries, and property damage
   - Improved management of weather-related delays and operating costs
   - Mitigation of adverse impacts of surface transportation operations on the environment.

2. Facilitate development and delivery of training and outreach materials to build the capacity of surface transportation constituents.

FUNDAMENTAL DEFICIENCIES

At present, National Weather Service (NWS) Weather Forecast Offices are able to provide only limited tailoring of forecasts to small geographic areas. They try to address transportation issues during seasonal and holiday periods (either in Special Weather Statements or Area Forecast Discussions), and some offices have attempted to inject probabilistic language into these products. However, the routine, general weather forecasts for county-size areas presently produced by the NWS do not provide adequate geographic coverage and the needed update frequency to meet the decision time frames of most drivers, maintenance managers, and traffic operations personnel. This shortfall in meeting user needs stems from three fundamental deficiencies.

The first deficiency is the lack of coverage of the most-relevant atmospheric and surface observations along roadway, rail, and transit systems. Over the past decade, the number and sophistication of weather observations has grown exponentially for various uses, but, in many cases, they are only partially useful in support of the operational decisions required for roadway, rail, or transit systems. Many states now realize that improved data on weather and road conditions could lead to better and more cost-effective decisions. They have invested in Road Weather Information Systems (RWIS) to support road maintenance, traffic management, and incident response. However, current methods or systems for collecting the data are inadequate for interpreting and delivering it in user-friendly form, within critical decision time frames, to all the agencies and personnel that could potentially use it.

The second deficiency is a lack of implementation awareness by potential users. In general, end users aren't aware of how to use current and planned weather services to improve their decisions because they have not been alerted to or trained on what data are available and what the data mean for their operations. This lack of understanding of how to use the information limits the effectiveness of transportation managers and operators. At the same time, weather forecasters often lack the application knowledge to interpret the implications of the data for the transportation system users.

The third deficiency lies in the inadequacy of diagnostic and forecast models to represent transportation-relevant conditions on the finer spatial and temporal scales necessary for operational decisions. Current forecast models do not adequately represent surface-level weather phenomena, dynamics, and interactions critical to assessing the impact of weather conditions on surface transportation modes at appropriate spatial and temporal scales. The spatial and temporal resolution of weather information needed for surface transportation applications in general, and for decision-support systems in particular, is typically in the misoscale horizontally (grid spacing of 40 meters to 4 km) and in a very shallow layer vertically (from ground level to levels equaling various bridge heights above it). To meet operational time lines, forecast updates must be rapid, on a scale of minutes to hours, and with lead times of 48 hours for initial preparations to respond.

INITIATIVES TO ADDRESS THE DEFICIENCIES

This document groups the WG/WIST's recommended initiatives into four general categories: observations, transportation weather decision support systems, improved training, and surface weather modeling and simulation. The second and third initiatives address the second deficiency in implementation awareness. The first and fourth initiatives address the deficiencies in surface transportation observations and modeling capabilities, respectively. The WG/WIST has not completed its work in prioritizing WIST R&D needs. Therefore, there is no priority order, implied or explicit, in the sequence of the initiatives or of the programs under an initiative.

INTEGRATION OF OBSERVATION DATA

The goal of providing the nation with timely, accurate, and relevant surface weather and condition information depends upon gathering and providing a large number of reliable observations from various sources, both surface- and space-based. The following efforts begin to build these needed observing systems and observation databases.

Integrate existing Road Weather Information System Environmental Sensor Stations (RWIS-ESS) into the National Surface Weather Observing System (NSWOS)

Objective – In coordination with the Clarus Initiative (see below), integrate Road Weather Information System-Environmental Sensor Station (RWIS-ESS) data into a National Surface Weather Observing System (NSWOS). NSWOS will form an observation subset of the U.S. Integrated Earth Observing System (IEOS), which will be a part of the Global Earth Observation System of Systems (GEOSS).

Background - Along the nation's highways, there are over 2,500 RWIS-ESS installed and operated by state and local transportation agencies. These stations provide observations of both meteorological variables, such as pressure, temperature, and winds, and road variables such as pavement temperature and road condition (e.g., wet, icy, flooded). A recent draft report from the AMS Forum on Weather and Highways states that "it has been clearly demonstrated that RWIS-ESS does benefit highway maintenance operations" and recommends that "the infrastructure be designed to ensure that (RWIS-ESS) data are collated on a national level and made available centrally."

The NSWOS will provide surface transportation-relevant data to government agencies (including emergency services and law enforcement), the private sector, the academic and research communities, and the general public. NSWOS is the operational evolution of NOAA's Meteorological Assimilation Data Ingest System (MADIS), a 4-year research investment. MADIS currently ingests meteorological and pavement variables from 16 state DOTs (as part of the over 17,000 mesonet observations from across the country every hour), and distributes quality-controlled (QC) information and observations to Federal, state, academic, and commercial organizations. MADIS is designed to ingest mesonet observations (in any format), combine the observations from different mesonet data providers, and QC and integrate them with other NOAA datasets by converting the observations to standard observation units, time stamps, and formats.

The MADIS data management architecture will provide the initial implementation of NSWOS. Initial operations of NSWOS will begin at the NWS Telecommunications Gateway (NWSTG) in FY07, including full system and communications backup. After this transition to operations, NSWOS will be an integral component in the collection and dissemination of data throughout NOAA and to the public.

<u>Leveraging</u> – Capturing RWIS-ESS network data available from participating states and leveraging nearby mesonets will aid in filling data gaps, reducing network costs, and meeting spatial and temporal requirements. Combining data from public, private, local, and national sources can also increase the accuracy of automated QC and data monitoring procedures designed to identify individual erroneous observations, as well as longer-term hardware and communication failures. These procedures are generally based on comparing neighboring observations and are therefore greatly aided by an increased density in the observational database.

Road weather information can be integrated into "intelligent dashboard" information systems for highway travelers. Courtesy OnStar Corp. Copyright 2002, all rights reserved.

Link the FHWA's surface transportation weather observation data management system with NSWOS (Clarus Initiative)

Objective – In coordination with the RWIS-ESS initiative described above, provide surface transportation weather information to all transportation managers and users to alleviate the affects of adverse weather (e.g., fatalities, injuries and delay) through development and demonstration of an integrated surface transportation weather observation data management system, and establish a partnership to create a Nationwide Surface Transportation Weather Observing and Forecasting System.

Background - Users of the surface transportation system need more timely, accurate and relevant road condition and weather information. In order to reduce the effects of adverse weather, the nation's network of weather and road condition observations must be modernized and integrated, and these data must be disseminated to the public and to surface transportation system operators. The Clarus Initiative is a joint effort of the U.S. DOT Intelligent Transportation Systems (ITS) Joint Program Office and the FHWA Road Weather Management Program, which resides within the Office of Transportation Operations.

Leveraging - *Clarus* will:

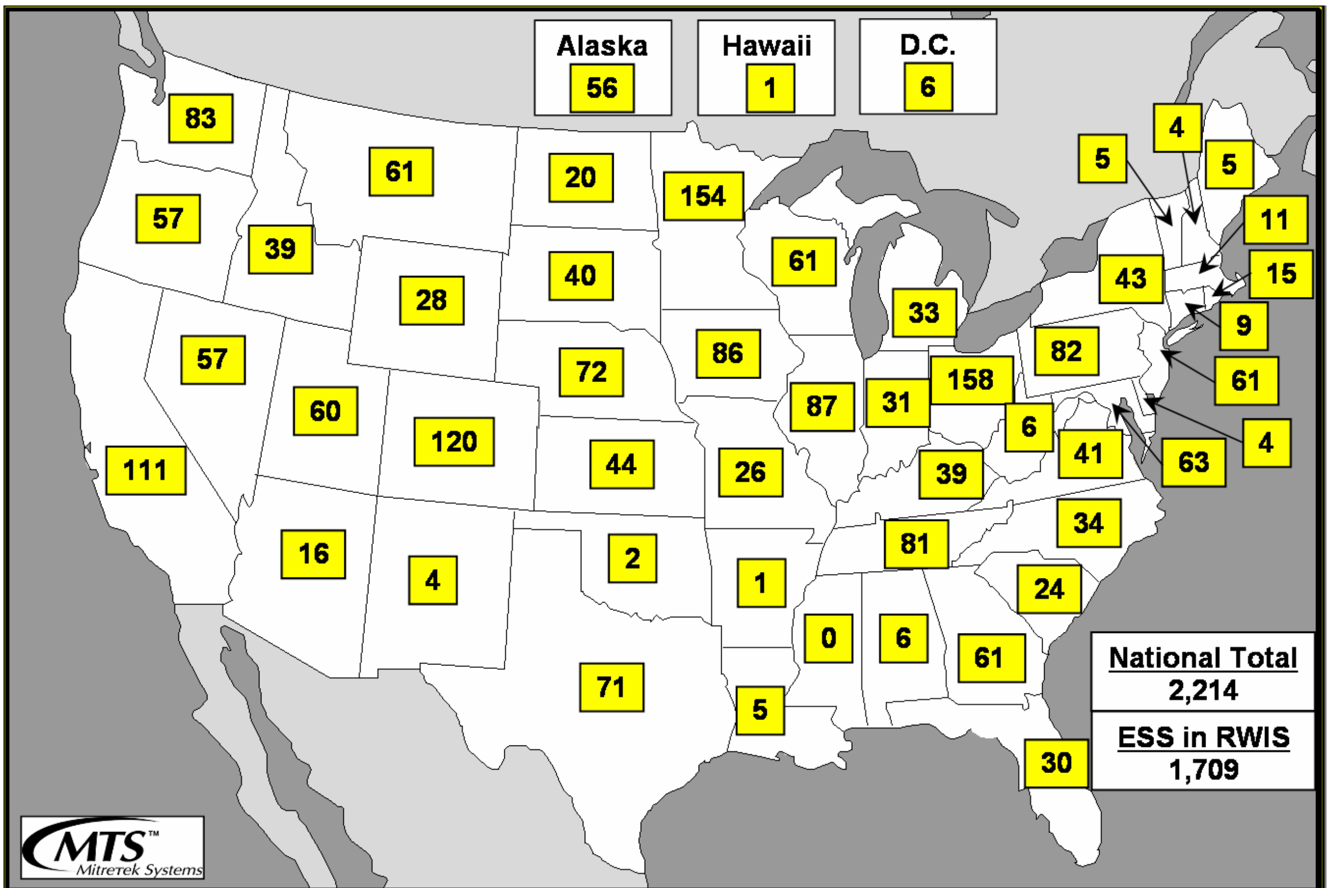
- Develop partnerships between the surface transportation and weather communities to leverage and share resources for both research and operations.
- Strengthen ties among Federal agencies such as the Federal Highway Administration (FHWA) and the National Oceanic and Atmospheric Administration (NOAA) that have similar objectives.
- Demonstrate a framework to collect the nation's current and future surface transportation weather and road condition observations, and provide quality data as input to advanced weather models to serve as the basis for value-added products and decision support tools.
- Establish an instrumented test bed to host new cutting-edge technologies for fixed, mobile and remote sensing.
- Establish an Initiative Coordinating Committee (ICC) to guide the development and deployment efforts (e.g., system design; design review; design proof-of-concept; the Multi-State Regional Demonstration; and the Model Deployment). The ICC will serve as an interdisciplinary source of expertise and guidance. ICC participants will consist of personnel from the FHWA, State DOTs, NOAA, other Federal agencies, the private sector, and academia. Meetings of the ICC will occur at least annually during the 6-year initiative.

As part of the WIST coordination initiative, the WG/WIST strongly recommends that NOAA and the FHWA explore points of technical collaboration and, ultimately, system integration between NSWOS and operational implementation of Clarus results.

Demonstrate the concept of the use of vehicle-based road condition probes (Vehicle Infrastructure Integration (VII) Initiative)

Objective: Evaluate the feasibility of using vehicles to gather, validate, and distribute surface weather and road condition data and information, and if practical, incorporate the data into the NSWOS. The aviation industry already follows this approach, e.g., the Aircraft Communication Addressing and Reporting System (ACARS), pilot weather reports (PIREPS), and other aircraft-borne sensors that take in situ observations.

Background: Useful information about surface weather and road conditions starts with good data. To meet the information needs of all surface transportation users and operators (e.g., commuters, transit operators, trucking companies, train operators), there is a need for dense data collection at the surface and particularly in the immediate vicinity of transportation routes (roads, highways, railways). To date, state and local transportation agencies have invested in over 2,200 fixed environmental sensor stations installed along the roadways, which have proven useful but insufficient due to many data gaps – both spatially and temporally. Vehicle-borne sensors may be a cost-effective way to fill many of these gaps. Data collected from sensors on vehicles would serve many purposes, including confirmation of current conditions, as a feed into numerical weather prediction (NWP) models, and as a component of advanced surface transportation weather and road condition information systems such as RWIS-ESS. When archived, these data will provide a usable source of historical data for future studies.



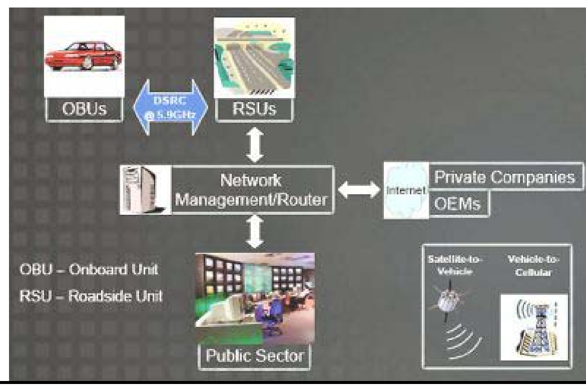
National RWIS-ESS deployment as of July 2006.

VII is an initiative of the U.S. DOT ITS Joint Program Office to test the feasibility of vehicle-to-vehicle communications and vehicle-to-infrastructure communications. This effort will combine several recent technological advances: precise GPS positioning technologies, calibrated onboard weather instruments, tire sensors, and vehicle-based remote sensing systems. Another name for this approach is Vehicles as Probes (VAP).

The Impact of VII on Decision Making: VII will test the capability of this technology to enhance response and planning through improvements to weather observations, models, and predictions for:

- Microscale events for immediate response (e.g., black ice, fog banks) conveyed in seconds to minutes
- Mesoscale events for tactical response (e.g., thunderstorms, flash floods) forecast in minutes to hours
- Synoptic scale events for strategic response (e.g. blizzards, floods, heat) forecast in hours to days

Leveraging: A number of ongoing efforts taking place in both the public and private sector minimize the risk and cost associated with the initial effort. This includes ongoing deployments by State DOTs to collect GPS and vehicle data, advancements in vehicle electronics by the automobile industry, and data assimilation advancements. The VII data will also be included in the NSWOS to help fill data gaps, as the data become operationally available.



The use of "Vehicles as Probes" offers the opportunity to collect weather observations along any instrumented highway or roadway.

Integrate satellite-based senor data into surface weather support systems

Goal: NASA will conduct, in partnership with other agencies, at both the Federal and state level, a roadway-sector-specific analysis of weather impacts, mitigation actions, and information needs for which satellite-based remote sensing may be useful. The goal of the initial effort is to specify the optical and thermal characteristics of roadways using satellite remote sensing data.

Objective: Conduct exploratory assessment of the Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) thermal imagery for estimating road surface temperature

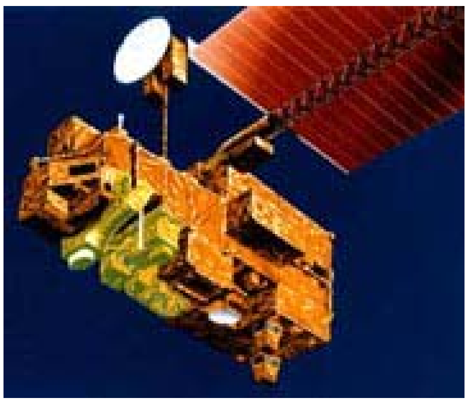
- Key parameter for winter road maintenance
- Primarily proof-of-concept to demonstrate applicability of NASA data to surface transportation

Background: The object of this effort is not to use ASTER as a weather prediction tool, but rather to characterize road thermal properties between RWIS-ESS stations, thereby enabling thermal-model enhancement. Assumptions that will be used are:

- 95 percent Confidence Interval

- Land surface variation within a 90-meter ASTER Temperature pixel can be explained by 3 dominant thermal types:
  - pavement
  - non-pavement: vegetation, soil
  - water
- ASTER reflectance and radiance models to remove atmospheric effects are fully effective

Leveraging: This effort will leverage already available science and research data to improve another agency's operational capabilities.



Satellite-based sensing of highway temperatures can help highway departments plan and update road-clearing operations. Each year, state and local agencies spend more than $2.3 billion on snow and ice control operations.

Demonstrate the concept of collaborative adaptive radar-based sensing of the atmosphere

In September 2003, the National Science Foundation established the Engineering Research Center for Collaborative Adaptive Sensing of the Atmosphere (CASA). This $40 million center brings together a multidisciplinary group to conduct fundamental research, develop enabling technology, and deploy prototype engineering systems based on a new paradigm for weather radar observations: Distributed Collaborative Adaptive Sensing (DCAS) networks. These revolutionary weather-sensing radar networks can save lives and property by detecting the region of the lower atmosphere currently below conventional radar range - mapping storms, winds, rain, temperature, humidity, airborne hazards, and other thermodynamic conditions. The radars will communicate with one another and adjust their sensing strategies in direct response to the evolving weather and changing user needs - a dramatic change from current technology. A new generation of meteorological software will use these radar data to support organizations that need weather data for decision making: government, emergency managers, and private industry.

Objective: The WG/WIST will provide the CASA team with WIST R&D needs so this ongoing research can be leveraged to meet surface transportation weather information needs.

Background: Revolutionary sensing technology that enables earlier and more accurate forecasts and warnings of weather emergencies is at the center of CASA's strategic plan. CASA is expected to increase the warning time for tornadoes, flash floods, and other severe weather disturbances while also providing more timely and accurate forecasts.

Sensing of the lower atmosphere and the detection, analysis, and prediction of hazards is only part of the challenge of observing, understanding, predicting, and responding to atmospheric hazards. The "last-mile problem" of effectively delivering data, products, and training to multiple end users - especially emergency managers, first responders, surface transportation decision makers and operators, etc. - is vitally important, yet often overlooked or unachievable based on the limitations of current approaches. Current technologies have single beams and non-overlapping coverage volumes, are not a coordinated network, and cannot be configured in response to specific end-user needs. Future technologies must be designed with the "last mile" as the "first mile," with end users involved in system design from the very beginning. CASA's DCAS network, with its many small radars and coordinated network, can be reconfigured to meet end user requests.

Leveraging: Surface transportation weather observations and predictions will be improved by making use of the results from the basic research conducted by this NSF-sponsored project. Under the WIST Integration of Observation Data Initiative, integration of the DCAS products, when operational, with NSWOS will be evaluated.

Integrated precipitable water vapor from the Nationwide Differential Global Positioning System Program

Objective – Continue development of new or improved remote sensing systems to observe moisture fields (including water vapor and clouds), and integrate those observations into the NSWOS and into weather forecast models to improve surface weather predictions. One such system uses ground-based GPS receivers to make accurate all-weather estimates of atmospheric refractivity. The first and most mature use of GPS for this purpose is in the estimation of integrated (total column) precipitable water vapor.

Background – While an important goal in modern weather prediction is the improvement of short-term cloud and precipitation forecasts, our ability to do so is severely limited by the lack of timely and accurate water vapor data. Prior to the demonstration of GPS atmospheric remote sensing in 1993, typical water vapor observing systems included radiosondes, surface-based radiometers, satellite-based radiometers, and some research aircraft. Each of these systems has advantages and limitations.

The planned purpose of the Nationwide Differential Global Positioning System (NDGPS) is to provide accurate positioning and location information to travelers, emergency response units, and other customers. The National Oceanic and Atmospheric Administration's Forecast System Laboratory in Boulder, CO, is measuring precipitable water vapor in the atmosphere. GPS receivers installed for the primary purpose of performing basic measurements and generating corrections are used to measure satellite signal delay. Data taken from these measurements is then correlated with the precipitable water vapor present in the atmosphere and data taken from other equipment installed at each NDGPS broadcast site to measure temperature, barometric pressure, and humidity. These data are fed into the National Weather Services forecast models, providing improved short-term weather forecast for all users, including transportation departments, and will become part of the NSWOS.

Leveraging - The NDGPS program is implemented jointly with the Department of Transportation's Federal Highway Administration, Federal Railroad Administration, and Office of the Secretary of Transportation; the Department of Homeland Security's U.S. Coast Guard; the Department of Commerce's National Geodetic Survey and NOAA's Forecast Systems Laboratory; and the Department of Defense's Air Force and Army Corps of Engineers.

TRANSPORTATION WEATHER DECISION SUPPORT SYSTEMS

For safe and efficient winter highway maintenance and operations, state and local transportation offices must know the current and forecasted road-weather conditions, have confidence that the information is accurate and reliable, and evaluate those conditions so that maintenance staff can allocate resources. To help address these issues, many state DOTs have deployed a RWIS, including environmental sensor stations, within their states. Many maintenance staffs also have access to a variety of other sources of information that can be used to help in winter maintenance. However, many state and local transportation offices have found that these different sources of information are not used as fully as anticipated and that the purchased systems do not meet their long-term expectations. Federal, state, and local transportation offices are working together to evaluate how they might make better use of RWIS-ESS data and other tools to make winter maintenance decisions, recommend improvements in the process and the equipment, and determine an appropriate tool to provide decision support.

Winter Weather, Winter Maintenance, and Airport Ground Operations Initiative

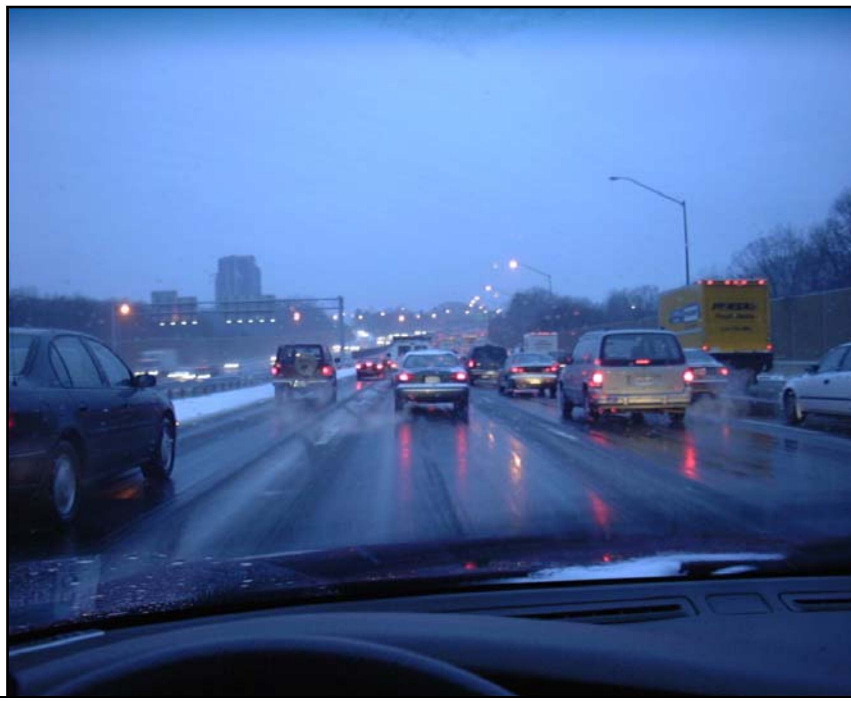
Objective - Significant benefits could be accumulated by both the surface weather and aviation communities by seeking collaborative efforts between the FAA's Aviation Weather Research Program and the FHWA's Maintenance Decision Support System (MDSS) in the area of winter weather prediction and winter maintenance decision support, to assist with airport ground operations and other surface weather winter operations and maintenance activities.

Background - Currently the FAA's Aviation Weather Research Program's *Winter Weather Product Development Team* has developed a product called the Weather Support to De-icing Decision-Making (WSDDM) system. Aircraft ground deicing and anti-icing operations can be costly. Costs include the cost of deicing fluid, the cost of deicing crews, and the cost of delays as a result of deicing activities. These operations also affect the airport departure rates, and therefore, National Airspace System capacity.

The purpose of WSDDM is to produce real-time, short-term forecasts in the terminal area to support ground deicing and terminal management during winter storm conditions. Winter weather conditions have a major impact on the safe and efficient operation of aircraft in the terminal area. By research conducted on several airline deicing accidents, the product development team (PDT) discovered that the impact of ice and snow on aircraft performance depends on the liquid water equivalent of the precipitation. The failure of deicing and anti-icing fluids that cause snow and ice to form on aircraft depends primarily on the anti-icing fluid concentration, liquid-equivalent precipitation rate, air temperature, and wind speed.

While WSDDM was being developed and deployed, the FHWA began developing a prototype winter Maintenance Decision Support System (MDSS). The objective of the MDSS effort is to produce a prototype tool for decision support to winter road maintenance managers.

The MDSS is based on leading diagnostic and prognostic weather research capabilities and road condition algorithms, which are being developed at national research centers. Components of the prototype MDSS system developed by this project are currently being deployed by road operating agencies, including state DOTs, and generally supplied by private vendors.



On freeways, light rain or snow can reduce traffic speed by roughly 10 percent. Heavy rain can decrease highway speeds by approximately 16 percent. In heavy snow, freeway speeds can decline by about 40 percent.

Several candidate road weather technologies currently exist at national laboratories, but the new technologies needed to be integrated, refined, and tailored to address winter road maintenance issues. It also became clear to the FHWA and NOAA that new and focused research must be conducted to address specific winter maintenance decision support needs that are not addressed by current technologies. The MDSS project has developed a prototype capability that:

- Capitalizes on existing road and weather data sources
- Augments data sources where they are weak or where improved accuracy could significantly improve the decision-making task
- Fuses data to make an open, integrated and understandable presentation of current environmental and road conditions

- Processes data to generate diagnostic and prognostic maps of road conditions along road corridors, with emphasis on the 1- to 48-hour horizon (historical information from the previous 48 hours will also be available)
- Provides a display capability on the state of the roadway
- Provides a decision support tool, which provides recommendations on road maintenance courses of action
- Provides all of the above on a single platform, with simple and intuitive operating requirements, and does so in a readily comprehensible display of results and recommended courses of action, together with anticipated consequences of action or inaction.

Leveraging – It is recommended that a group be established of program experts from the WSDDM and the MDSS projects to see where each program can be leveraged to further improve both aviation and surface weather information support in a collaborative manner.

IMPROVED TRAINING FOR TRANSPORATION WEATHER APPLICATIONS

The aspect of training described below will address the immediate needs of transportation operators and weather information providers, build upon existing materials, and help to reduce weather-related crashes, injuries, and fatalities.

Training for transportation operations on making the most of NWS products and services

Objective – The preparation of training materials for the purpose of educating transportation decision makers on existing and newly developed tools that provide easily accessible and understandable information.

Background: Training comes out of a documented need expressed by transportation decision makers for enhanced training on weather hazards, warning coordination, and communication. Training should be designed to encourage participant interaction for maximum efficiency. The targeted audience should include decision makers for all modes of surface transportation.

Leveraging – The NWS and FEMA have developed training modules to assist the emergency management community attain a better understanding of data and products produced by the NWS. These courses, although developed for emergency management decision makers, can be modified to satisfy the needs of the transportation decision makers.

Training for NWS field staff on needs of transportation decision makers

Objective – Training NWS field staff on the needs and capabilities of transportation decision makers as users of NWS products and information. Continuing education will be required beyond the development of the initial training efforts.

Leveraging – Provide NWS forecasters with access to state and Federal DOT training opportunities to acquire a better understanding of the needs and difficulties experienced by transportation decision makers when using surface weather information.

Training for transportation operations on a prototype database for surface transportation

Objective – Provide training and demonstration information to surface transportation weather information users on how to use existing NWS forecast grids that focus on near-surface information and forecast elements.

Background – The NWS has a limited number of experimental forecast grids of weather elements (e.g., maximum and minimum temperatures, cloud cover, probability of precipitation) available in what is called the NWS National Digital Forecast Database (NDFD). In addition, national graphics and images from 16 predefined geographic sectors will be made available to the public in 5-km resolution, and will allow those customers and partners to create a wide range of text, graphic, and image products of their own.

The NDFD contains a seamless mosaic of NWS digital forecasts from NWS field offices working in collaboration with NWS National Centers for Environmental Prediction (NCEP). With time, a wider array of forecast elements will be available in the database as will a larger set of graphical presentations.

Leveraging – The NWS already has heavily invested in the development of the NDFD, its initial forecast elements, and other parameters under present development, including visibility and ice coverage. These national mosaics are at 5-km resolution. Users can currently access this experimental data via the Internet and ftp servers.

SURFACE WEATHER MODELING AND SIMULATION

Surface weather modeling and simulation (SWMS) technologies – computers, model software, and statistical post-processing – are evolving rapidly. This category of cooperative work between NOAA and other WIST-user organizations is intended to ensure that the particular needs of WIST users are met via a continuing program of research and development to improve existing techniques, applications, and products. The value of targeted SWMS R&D, coordinated jointly by users, developers, and implementers, is analogous to the value of advances in aviation weather forecasting services achieved by the FAA's Aviation Weather Research Program. Partnering of users, developers, and implementers is one type of interagency relationship envisioned for supporting the WIST-user community.

As described in the 2002 *WIST Report*, the adverse effects of rain on roadway, railway, transit, airport ground operations, and pipeline systems account for a large part of the weather impacts on these transportation sectors. Preparations for and response to these precipitation events would be improved if transportation decision makers had reliable nowcasts (current to 3 hours) at the high spatial resolutions needed to assess highly localized effects on transportation systems.

Statistical guidance initiative for improved prediction of precipitation

Objective – Improve already existing short-range statistical guidance by incorporating additional surface weather observations, and, where possible, extend short-range statistical guidance techniques to established RWIS-ESS sites.

Products of desired elements fitted to desired locations will be produced and made available publicly, after the appropriate experimental evaluation and comment period. This weather "intelligence" must meet the specific planning needs of transportation users, e.g. by type of trip. A long distance traveler may want a 24-48 hr forecast over a large geographic area, but a commuter only wants nowcast information (0-90 mins) for a specific segment of roadway.

Background - The Model Output Statistics (MOS) technique develops prediction equations from both observed and model forecast weather elements, which are then applied to raw model output (the same or similar model) to produce statistical guidance. Because MOS uses NWP output in both the development and implementation of the statistical equations, time lag can be incorporated into the relationships as well as an accounting of certain systematic model errors such as a dry bias. MOS calibrates observations at specific locations that are between grid points in the models to NWP forecasts. It can produce probabilistic forecasts for common weather elements, as well as forecasts for elements not predicted directly by models.

The MOS interprets NWP models based on historical sampling and is used to predict events forced by synoptic-scale systems, while accounting for both local effects and climate. In making forecasts, the MOS uses three types of input information, namely, NWP model forecasts, prior observations, and geoclimatic data. In the NWS, the MOS approach is part of the complete end-to-end forecast process and is currently applied to both the Eta and Global Forecast System models to provide objective interpretive guidance.

MOS is already used to provide short-range text messages of maximum and minimum temperatures and probabilistic and categorical snowfall amount forecasts for over 1,500 hourly observing locations and over 4,700 NWS Cooperative Observer Network (COOP) sites around the nation.

Leveraging –Gridded MOS guidance in graphical formats on a high resolution, 5 km grid (similar to the grid used by the NDFD) have recently become available on an experimental basis. Twenty-four hour snowfall amounts were among the first elements developed. Other elements include maximum and minimum temperature, probability of precipitation, and probability of thunderstorms. The equations for the weather elements used in the "MOS for COOP" methodology could be applied to critical locations defined by partnered Federal, state, and local agencies that would benefit the road weather community. In this case, products such as snowfall amount could be generated for RWIS sensor locations. This activity has the advantage of taking existing, regionalized equations for elements such as snowfall amount and applying them to new locations. RWIS sites are not currently included in MOS guidance. Another option to expand MOS would be to take RWIS locations that meet existing sensor (the environmental sensor station (ESS) at the location) and climatological requirements, and begin work to apply the MOS approach to the data obtained at these locations. This would provide users with more specific information tailored to the relevant sites, but entails developing the equations to fit to the new sites.

FUNDING FOR THE WIST INIATIVES

Partnering is needed to achieve the R&D objectives of these four WIST initiatives and to secure and maintain advocacy and funding for infusing the developed technology into operations. New relationships among public and private sector groups will require changes in how Federal agencies support, coordinate, and participate in the rapidly expanding WIST-provider community. The vision of a vastly improved, safe, and efficient transportation system requires WIST users and providers to leverage research plans and funding in a mutually beneficial way. With Federal leadership, these communities must work together to apply the results of weather research and technology development to the spectrum of decision processes needed for surface transportation activities. Wherever possible, agencies are encouraged to seek cost-sharing arrangements with other surface transportation stakeholders to marshal scarce resources and accelerate improvements in surface transportation products and services.

SUMMARY AND CONCLUSION

For surface transportation, the unintended consequences of weather-related incidents, accidents, and crashes include fatalities, injuries, property damage, lost productivity, reduced capacity, and delays. These consequences are similar to those occurring from weather events and conditions that affect the aviation sector. Much can be learned from the aviation sector's focused and successful approach to R&D (see Appendix D) to improve WIST services and capabilities.

This document represents the WG/WIST members' early recommendations on key actions for the responsible agencies in the OFCM Federal coordinating infrastructure to collaborate and address national surface transportation safety, mobility, and productivity issues. The WG/WIST has identified three deficiencies and four coordination initiatives to address them. The initiatives focus on observations, decision support systems, training, and surface weather modeling and simulation. These initiatives will begin the process of achieving the initial vision and goals selected by the WG/WIST for the WIST R&D Plan, which it is developing to increase the safety, mobility, and productivity of our Nation's surface transportation systems. While completing these initiatives is only the first step, this step is significant for demonstrating the benefits gained when the responsible Federal agencies can develop shared vision, together with the needed resources, to begin to address national surface transportation safety, mobility, and productivity issues.

REFERENCES

- *Weather Information for Surface Transportation - National Needs Assessment Report,* NOAA/OFCM, December 2002
- *Research in NOAA: Toward Understanding and Predicting Earth's Environment, A Five-Year Plan: Fiscal Years 2005-2009,* January 2005
- *Strategic Plan for the U.S. Integrated Earth Observation System,* National Science and Technology Council, Apr 2005 (http://iwgeo.ssc.nasa.gov/docs/EOCStrategic_Plan.pdf)
- *FAA Aviation Weather Research Program (AWRP),* AWRP web site, last updated October 15, 2004, http://www.faa.gov/aua/awr/
- *NOAA Surface Weather Program (SWP),* SWP web site, last updated February 1, 2005, http://surfaceweather.noaa.gov/index.html
- NOAA's National Weather Service, Office of Science and Technology*, Science and Technology Infusion Plan, 2004, http://mi.nws.noaa.gov/ost/*
- *Weather and Highways –Report of a Policy Forum,* American Meteorological Society, November 2003
- *Where the Weather Meets the Road: A Research Agenda for Improving Road Weather Services,* Board on Atmospheric Sciences and Climate, January 2004
- *Weather-Related Crashes on U.S. Highways in 2001*, Lynette C. Goodwin, Mitretek Systems, Inc., December 19, 2003
- *Analysis of Weather-Related Crashes on U.S. Highways***,** Lynette C. Goodwin, Mitretek Systems, Inc., December 24, 2002
- *Weather Impacts on Arterial Traffic Flow*, Lynette C. Goodwin, Mitretek Systems, Inc., December 24, 2002
- *Analysis of Weather Impacts on Traffic Flow in Metropolitan Washington DC*, Andrew D. Stern*, Vaishali Shah, and Lynette Goodwin, Mitretek Systems, Inc., Falls Church, VA, Paul Pisano, Federal Highway Administration, Washington, D.C.
- Highway Statistics 2003, **"***Providing information to address major transportation issues facing the Nation.***"** Office of Highway Policy Information **-** Federal Highway Administration
- The **Minerals Management Service** (MMS), a bureau in the **U.S. Department of the Interior,** homepage. MMS is the Federal agency that manages the nation's natural gas, oil and other mineral resources on the **outer continental shelf** (OCS). The MMS and the oil and gas industry work cooperatively to protect our environment and to keep workers safe. One method of monitoring the success of this effort is to identify accident trends and safety concerns. The OCS Lands Act requires either the MMS or the U.S. Coast Guard (USCG) to prepare a public report for all deaths, serious injuries, major fires, and major oil spills resulting from OCS exploration, development, or production operations. Each year, MMS compiles a comprehensive report that lists all OCS-related incidents under MMS jurisdiction that occurred during the calendar year. These reports entitled "**Incidents Associated with Oil and Gas Operations**" can be found at http://www.mms.gov/incidents/
- U.S. DOT "Performance and Accountability Report 2003 (www.dot.gov/perfacc2003/ataglance.htm)
- 2005 National Transportation Statistics report (http://www.bts.gov/publications/national_transportation_statistics/2005/index.html)
- Pocket Guide to Transportation 2005, The Transportation Network: 2003, Table 1, www.bts.gov/publications/pocket_guide_to_transportation/2005/html/table_01.html)

- Highway Statistics 2003, www.fhwa.dot.gov/policy/ohim/hs03/htm/mv1.htm)
- 2004 Transportation Statistics Annual Report, Transit Ridership, www.bts.gov/publications/transportation_statistics_annual_report/2004/html/chapter_02/transit_ridership.html)

Appendix A

Working Group for Weather Information for Surface Transportation (WG/WIST) Member Agencies

Department of Agriculture	Mr. Bradley Rippey
Department of Commerce	Mr. Mike Campbell**
Department of Defense (Navy)	Mr. Terrance Tielking
Department of Defense (AF)	Col. Mark Weadon
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Federal Railroad Administration (DOT)	Ms. Jo Strang
Federal Transit Administration (DOT)	Ms. Charlene Wilder
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Environmental Protection Agency	Mr. Robert Gilliam
National Aeronautics and Space Administration	Mr. Martin Frederick
National Science Foundation	Dr. Pamela Stephens
National Transportation Safety Board	Mr. Donald Eick
U.S. Nuclear Regulatory Commission	Ms. Leta Brown
Office of Management and Budget	Ms. Erin Wuchte

** WG/WIST Co-chairs

Appendix B

Examples of Weather Impacts on Safety, Mobility, and Productive

The nation's surface transportation systems touch our lives many times each day. They connect consumers with resources and enable us to travel where we need or desire to go. Nearly every citizen uses or relies on these systems daily—including the 3.9 million miles of public roads, 2.1 million miles of oil and natural gas pipelines, 122,000 miles of major railroads, and over 26,000 miles of commercially navigable waterways. Transportation services were provided at nearly 5,300 public-use airports and over 14,000 private use airports in 2004 (Source: 2005 National Transportation Statistics report, Number of U.S. Airports, Table 1-3), throughout the over 6,800 miles of commuter rail in 2003 (Source: 2005 National Transportation Statistics report, System Mileage within the United States, Table 1-1), and at 321 ports on the coasts, Great Lakes, and inland waterways and over 9,400 commercial waterway facilities in 2002--waterway facilities as counted by the U.S. Army Corps of Engineers are piers, wharves, and docks. Not included are those facilities used exclusively for recreational or active military craft and generally those providing non-maritime use. (Source: Pocket Guide to Transportation 2005, The Transportation Network: 2003, Table 1). The total value of the national transportation infrastructure in 2003 was about $1.2 trillion, and 10.5 percent of the gross domestic product (GDP), or about $8 trillion, was related to transportation (Source: 2005 National Transportation Statistics report, GDP by Major Social Function, Table 3-5). Weather influences virtually every type of operation or activity involved in these transportation systems and facilities.

HURRICANE KATRINA IMPACT ON SURFACE TRANSPORTATION SYSTEMS
News clips August 25 – September 8, 2005

1. Shipments of grain and other commodities languish on barges unable to pass through New Orleans ports closed by Hurricane Katrina.

   a. Unclear when New Orleans (NO) ports will reopen…NO traditionally handles more than half of the country's grain exports to overseas destinations.

   b. Impact felt across the Midwest…without access to oceangoing vessels, grain elevator operators have reduced prices they are paying growers.

2. A logistics team working on delivering chocolate from Ohio to South Carolina was having trouble finding truckers to take the shipment. Refrigerated trucks at a premium because they are hauling ice for relief efforts, and truckers are reluctant to drive where diesel fuel may be in short supply…there were reports of fuel rationing as far north as Tennessee.

3. While freight train service into the stricken region resumed, it had to do so without power, meaning employees must use portable generators to recharge crossing gate batteries.

4. Interstate 10 and Interstate 12 between Baton Rouge, LA., and Pensacola, Fla., bear the scars of Hurricane Katrina…trees blocked lanes east of Hammond, the eastbound bridges near Pascagoula shut down because it shifted, and the tunnel flooded at Mobile.

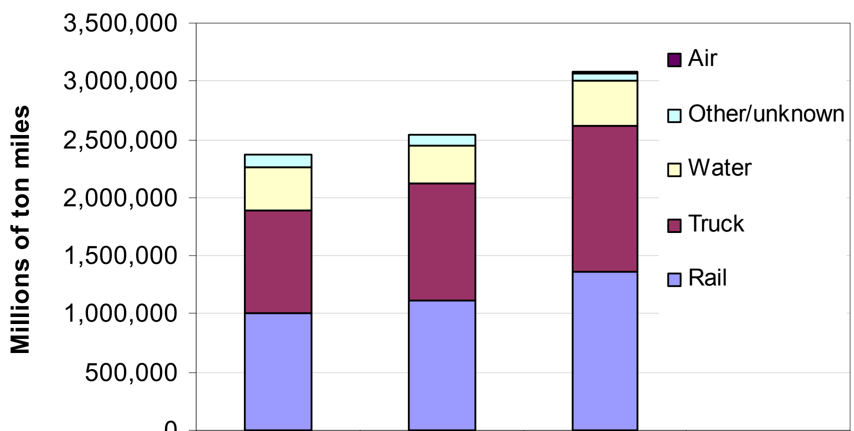
5. The Tennessee Department of Transportation halted all interstate and major highway construction work statewide over the Labor Day Weekend to accommodate increased traffic caused by people seeking refuge from Hurricane Katrina.

6. Mississippi's only impassable major road is U.S. 90. It's out of commission indefinitely across much of the state.

7. More than 91 percent of oil production and 83 percent of gas production in the Gulf of Mexico region was shut down because of damage to rigs and refineries caused by the hurricane. As a result, US motorists are already facing gasoline at $3 a gallon and may have to pay as much as $4 before long - a huge rise compared with an average price of just $1.86 a year ago.

8. IPSCO said its steel plant in Mobile, Alabama, is producing normally in the wake of Hurricane Katrina, but storm damage to the Gulf region's infrastructure is affecting freight shipments. The company said that barge and rail service to the west of its Mobile plant was damaged by Katrina and must be rerouted. IPSCO said availability of truck transportation has been affected by the shortage of fuel and increased demand caused by the disruption of barge and rail service.

The scale of use of surface transportation systems in the United States is impressive. There were more than 196 million licensed drivers (Source: Highway Statistics 2003, www.fhwa.dot.gov/policy/ohim/hs03/ xls/dlchrt.xls) and more than 231 million registered motor vehicles (Source: Highway Statistics 2003, www.fhwa.dot.gov/policy/ohim/hs03/htm/mv1.htm) used the nation's highways in 2003. Commuters number about 115 million, and 34 million of them travel more than 45 minutes each way. Of the more than 9 million recreation vehicles, 1.1 million are on the road at any given time. Of the more than 3 million truckers, about 1.1 million are long-distance haulers. Rental cars (including vans and SUVs) numbered about 1.5 million in 2003 (Source: 2005 National Transportation Statistics report, U.S. Automobile and Truck Fleets by Use, Table 1-14). On the nation's waterways, ferryboats carry about 134 million passengers each year, with more than 12 million recreational boats in use in 2003 (Source: 2005 National Transportation Statistics report, Number of U.S. Aircraft, Vehicles, Vessels, and Other Conveyances Table 1-11). In addition, cruise ships provide service to 5 million passengers every year (DOT 1999). Heavy-rail ridership posted 2,688 million trips; commuter rail, 414 million trips; and light rail, 337 million trips in 2002. There were 5,268 million bus trips. Other modes, such as ferryboats, posted a combined 311 million trips. (Source: 2004 Transportation Statistics Annual Report, Transit Ridership, www.bts.gov/publications/transportation_statistics_annual_report/2004/html/chapter_02/transit_ridership.html)



	1992	1997	2002	Pct Ch 1992-2002
Air	3,781.00	5,802.00	5,659.00	49.7
Other/unknow n	105,732.00	89,705.00	63,257.00	-40.2
Water	377,240.00	327,804.00	383,260.00	1.6
Truck	880,890.00	1,003,611.00	1,261,813.00	43.2
Rail	1,003,552.00	1,113,674.00	1,360,760.00	35.6

Figure 1-1. U.S. Total Modal Activity by Ton Miles (in millions), Reported in the Commodity Flow Survey: 1992, 1997 and 2002

Parts of our surface transportation system function at or near their maximum capacity much of the time, and capacity utilization is increasing. All surface transportation modes have congestion at critical bottlenecks. Weather reduces the capacity throughout the system, creating new bottlenecks and exacerbating existing ones. Actions that mitigate these weather effects improve transportation system safety and efficiency. Weather also has daily impacts on the goods carried by the nation's Marine Transportation System and its intermodal connections to rail, motor carrier, pipeline, and air cargo transportation systems. These impacts affect the transit time, delivery reliability, efficiency, and cost of all goods transported by these systems.

Weather Impacts on Safety

- Weather acts through visibility impairments, precipitation, high winds, and temperature extremes to affect driver capabilities, vehicle performance (i.e., traction, stability and maneuverability), pavement friction, roadway infrastructure, and crash risk.
- In 2002, over 23 percent of all vehicle crashes on U.S. highways occurred under adverse road weather conditions. That is, 1,451,000 crashes occurred in the presence of rain, snow, sleet, fog, wet pavement, snowy pavement, slushy pavement or icy pavement. Over 7,200 people were killed and more than 588,000 people were injured in these weather-related crashes.
- *Preliminary* statistics for weather-related crashes over an 8-year period (1995-2002) show that on average there were over 1,570,000 weather-related crashes each year. This accounts for 24 percent of all vehicle crashes. The number of people killed in weather-related crashes each year was over 7,300. That is 17 percent of all crash fatalities. The number of people injured in weather-related crashes each year was over 713,000. That is 22 percent of all crash injuries.
- <u>In contrast</u>, the combined 10-year average for flood, lightning, tornado, hurricane, heat, cold and winter storm fatalities in the U.S. is 251.
- The Coast Guard attributes seven percent of recreational boating accidents to weather.
- Elko, NV, August 2005 - At least four people were killed and a dozen or more were injured when 18 vehicles, their drivers blinded by swirling dust and ash, collided on Interstate 80, west of Elko. The chain-reaction highway wreck shut down eastbound lanes of the freeway about 25 miles west of Elko. Westbound drivers on the main east-west highway through Nevada were delayed as emergency vehicles moved in and out of the crash scene. Four people were confirmed dead and the number of injured are at least a dozen. The poor visibility was caused by high winds that picked up dust and ash from land near the freeway that had burned about three weeks before. The vehicles that rear-ended one another included four to five big trucking rigs as well as passenger vehicles and pickups.
- Water taxi passengers were thrown into the frigid waters of Baltimore's Inner Harbor on March 6, 2004, when a 36-foot seaport taxi capsized in a sudden thunderstorm with wind gusts of up to 55 mph. This incident occurred 100 yards offshore from historic Fort McHenry in 44-degree water. The tragedy claimed the lives of five passengers, including a 6-year-old boy.
- Another incident, this one involving an Amtrak passenger train derailment, illustrates how weather conditions can cause problems specific to a transportation system's infrastructure and operations. July 29, 2002, was an excessively hot day in the Mid-Atlantic region. As the Capitol Limited sped through Kensington, Maryland, the engineer applied the train's emergency brakes after spotting an area of misshapen track ahead. The multiple car derailment 45 seconds later left bleeding passengers crawling

out the windows of overturned cars. A total of 101 passengers were injured, with one still in serious condition the next day. Experts considered the most likely cause of the 30-inch misalignment of the welded track to be buckling due to the hot weather. A heat order issued that day had reduced the posted speed for freight trains from 55 to 45 miles per hour (mph), but not the 70 mph speed limit for passenger trains. The line remained closed to all traffic until the derailed cars could be removed and the damaged track replaced. Although the number of derailments due to heat buckling of rails has declined, there were 44 accidents attributed to this weather-related condition in 2001 (Manning 2002).

- In October 1994, a major flood on the San Jacinto River near Houston undermined numerous pipelines. Eight pipelines ruptured, igniting petroleum spills into the river. More than 500 people suffered burn injuries. Effects of weather phenomena are the second-most frequent contributor to pipeline damage or failure. (Source: NTSB 1996.)
- February 22, 2003, a passenger on a single-engine helicopter received fatal injuries during a hot refueling operation. The helicopter had landed at the platform for an intermediate fuel stop en route to a West Cameron platform. During the refueling operation a wind gust started to push the helicopter about the platform. The pilot immediately began to shutdown the helicopter engine and applied the main rotor blade brake. The helicopter came to rest approximately one foot from the edge of the platform. After the helicopter came to rest, the pilot noticed that the main rotor blades had struck a passenger. The NTSB cited the pilot's failure to maintain directional control of the aircraft during the hot refueling operation as the probable cause with high winds contributing to the accident.
- Hazardous materials are shipped via many modes of transportation in the roadway, rail, MTS, and airport ground operations sectors covered in this study. If a release of hazardous materials occurs, atmospheric transport and diffusion of hazardous substances becomes an immediate concern of the public safety and emergency response teams involved. Major arteries may be closed, and populated areas at risk of exposure may need to be evacuated quickly. The weather may or may not play a role in causing a hazardous release. However, emergency response managers always need to know how the weather will affect the dispersion of materials and their plans for containing the damage and recovering.

Weather Impacts on Mobility

- Roadway capacity reductions can be caused by lane submersion due to flooding and by lane obstruction due to snow accumulation and wind-blown debris. Road closures and access restrictions due to hazardous conditions (e.g., large trucks in high winds) also decrease roadway capacity.
- On signalized arterial routes, speed reductions can range from 10 to 25 percent on wet pavement and from 30 to 40 percent with snowy or slushy pavement. Arterial traffic volumes can decrease by 6 to 30 percent depending on road weather conditions and time of day. Travel time delay on arterials can increase by 11 to 50 percent depending on severity of the weather event. (Source: Mitretek Systems, *"Weather Impacts on Arterial Traffic Flow*", 2002).
- On freeways, light rain or snow can reduce traffic speed by roughly 10 percent. Heavy rain can decrease highway speeds by approximately 16 percent. In heavy snow, freeway

speeds can decline by about 40 percent. It has been estimated that 23 percent of the non-recurrent delay on highways across the nation is due to snow, ice, and fog. This amounts to an estimated 544 million vehicle-hours of delay per year. (Sources: "*Highway Capacity Manual 2000" Chapter 22 & Oak Ridge National Laboratory,* "*Temporary Losses of Highway Capacity and Impacts on Performance.*") Additional delays are caused by rainfall and wet pavement.

- During adverse weather, average travel time delay increases by 14 percent in Washington, D.C., and by 21 percent in Seattle, WA. During peak periods in Washington, D.C. travel time increases by roughly 24 percent in the presence of precipitation. (Source: Mitretek Systems, *Analysis of Weather Impacts on Traffic Flow in Metropolitan Washington DC*, 2003)
- Risks from exposure to adverse weather conditions are increasing in other ways as well. Certain elements of the population, such as those who are elderly, disabled, or have a low income, are more severely affected by weather impacts on their modes of transportation than the average citizen may be. In the 2000 census, persons 65 and older were 12.6 percent of the population. The Census Bureau expects this fraction to rise to 20 percent by 2030 (Kinsella and Velkoff 2001, pp. 133-134). Many of the elderly rely on rural and urban transit systems, which are subject to delays and cancellations in adverse weather. As a second example, the Census Bureau reports that one fifth of all Americans and nearly half of all senior citizens over age 65 have some level of disability (McNeil 1997). The routine of scheduled, accessible transit operations is a key factor in enabling people with disabilities to find and accept employment and to participate in other daily life activities. Because the number of people with disabilities is likely to increase as the population ages, the total risk from adverse weather impacts on their modes of transportation will increase.

Weather Impacts on Productivity

- Adverse weather can increase operating and maintenance costs of winter road maintenance agencies, traffic management agencies, emergency management agencies, transit operators, law enforcement agencies, and commercial vehicle operators (CVO).
- Winter road maintenance accounts for roughly one-quarter of state DOT maintenance budgets. Each year, state and local agencies spend more than 2.3 billion dollars on snow and ice control operations, and over 5 billion dollars to repair infrastructure damage caused by snow and ice. (Sources: *"Highway Statistics Publications," http://www.fhwa.dot.gov/policy/ohpi/hss/hsspubs.htm*)
- Each year trucking companies or CVOs lose an estimated 32.6 billion vehicle hours due to weather-related congestion in 281 of the nation's metropolitan areas. Nearly 12 percent of total estimated truck delay is due to weather in the 20 cities with the greatest volume of truck traffic. The estimated cost of weather-related delay to trucking companies ranges from 2.2 billion dollars to 3.5 billion dollars annually. (Source: "*Analysis of Weather Incident Effects on Commercial Vehicle Mobility in Large U.S. Cities," Mitretek Systems*).
- The Marine Transportation System offers a telling illustration of how these essential transportation systems can be affected by weather. This system comprises the nation's navigable waterways, ports, and harbors, as well as the connections to railroad, roadway, and pipeline systems. It enabled the United States to become the world's

leading maritime trading nation; over 95 percent of U.S. foreign trade tonnage is shipped by sea (DOT 1999), and more than 38 percent of intercity freight is carried on inland waterways and pipelines (Coyle et al. 2000). On February 27, 2001, fog closed the Houston ship channel to inbound traffic, causing long delays for vessels using this waterway. Similar conditions caused a backlog of almost 80 ships earlier in the month. Houston and neighboring ports are home to the nation's largest oil and petrochemical plants. Fog along the Gulf Coast was cited as the main reason for a huge, 12 billion barrel decline in the output of U.S. refineries that week. (Reuters 2001).

- Calgary, Alberta, June 2005: Inter Pipeline Fund advised its customers and investors that Empress II and Empress V extraction facilities were temporarily shut down as a result of severe weather. The storm has resulted in power outages and damages that are impacting area facilities. Empress II and Empress V were shut down while the situation and damages were assessed. Crude oil deliveries to the Bow River pipeline system in the Empress and Jenner areas were also impacted by the regional power outages.
- Pyramid Lake, CA., March 2005-- A weather-related landslide ruptured a high-pressure, 14-inch oil pipeline causing about 3,000 barrels of crude to flow into the lake. The California Department of Transportation (Caltrans) closed one lane in each direction on the freeway at Vista Del Lago to provide a staging area for crews involved in the clean up operation. Caltrans expected the lanes to remain closed for seven to 10 days. The pipeline ruptured about a quarter-mile from the lake, and the oil went into a creek, flowed under the freeway, then into the lake. The spill was caused by a landslide, apparently caused by rain.

Appendix C

Weather Information for Surface Transportation Background Information

In December 2002, the Office of the Federal Coordinator for Meteorological Services and Supporting Research (OFCM) published the comprehensive report, W*eather Information for Surface Transportation - National Needs Assessment Report*. This publication, prepared by the OFCM's Joint Action Group for Weather Information for Surface Transportation (JAG/WIST), provides the first-ever compilation of weather support needs across the six surface transportation sectors--roadway, railway, transit, marine transportation, pipeline systems, and airport ground operations--and an analysis of these needs. The findings in the report provide a framework for actions to substantially improve surface transportation operations in the future.

For the WIST Report and this report, the term *mode* best describes a narrower, more specific form of transportation, such as automobile, bus, truck, ferry or subway train. The term *sector* is broader in scope and encompasses multiple modes that share a major characteristic, such as the medium in which they operate (on water, on roads, on railways, in the air, etc.) or operation under one management (e.g., transit authorities). This report covers six transportation sectors:

- Roadway—state and Federal highways, roads, and streets
- Long-Haul Railway—rail lines providing intercity freight and passenger service, with their yards, stations, and depots
- Marine Transportation System (MTS)—coastal and inland waterways, ports and harbors, and the intermodal terminals serving them
- Rural and Urban Transit—bus and van service on streets and roadways, 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 pipelines
- Airport Ground Operations— Aircraft movement, vehicle movement, gate accessibility, aircraft maintenance, refueling aircraft, foot traffic, and construction and maintenance projects.

The JAG/WIST report also made a number of recommendations for future work, regarding WIST R&D needs, which were endorsed by both the Interdepartmental Committee for Meteorological Services and Supporting Research (ICMSSR) and the Federal Committee for Meteorological Services and Supporting Research (FCMSSR). Among the recommendations was the need to identify and specify gaps in coverage of WIST user needs, expand coordination among WIST R&D programs and WIST providers, translate research results and new technologies into WIST applications, provide the fundamental knowledge to support future technology development and application, and expand WIST-related outreach and education.

On August 18, 2003, Ms. Mary E. Peters, Administrator of the Department of Transportation/ Federal Highway Administration (FHWA), and VADM Conrad C. Lautenbacher, Jr., USN (Ret.), Under Secretary of Commerce for Oceans and Atmosphere and Administrator of the National Oceanic and Atmospheric Administration (NOAA), met to begin a dialog regarding the next steps to take in the area of Weather Information for Surface Transportation (WIST). Ms. Peters indicated that the WIST Report documented not just FHWA needs, but all of DOT's requirements, and she wanted to begin discussions with NOAA senior leadership on how NOAA and FHWA could work together to meet those needs and requirements. The FHWA's first concern is enhancing roadway safety, followed by improving efficient transportation regardless of the weather conditions experienced by surface transportation operators.

Subsequently, the OFCM hosted a series of NOAA-FHWA meetings of middle- to upper-level leadership representatives beginning on October 24, 2003. This informal meeting of NOAA-FHWA representatives concentrated on developing ideas and discussing strategy and plans for near-term, intermediate-term, and long-term activities for WIST. The initial ideas focused on initiatives in five categories: Training, Observations, Numerical Weather Prediction, Databases/Decision Support, and Information Dissemination.

The AMS Policy Program held a Policy Forum on Weather and Highways on November 4-5, 2003, to address the issues connected with effective use of road weather information. Given the enormous impact weather has on the highway system and the potentially huge safety and economic benefits that could be realized if weather information was used more effectively by road operating agencies and the public, why has it not received the attention it deserves? What has or has not been done to promote road weather services, what opportunities are emerging, and what impediments are in place that have slowed progress to date? What policies, if any, are needed at the Federal and/or state levels?

In an effort to discuss responses to these questions, the Atmospheric Policy Program of the American Meteorological Society (AMS) developed a forum to foster vigorous policy level dialogues. These dialogues led to recommendations on how to improve the safety and operations of the nation's highway system through better application of weather information. The forum brought together representatives of the weather information providers; transportation managers and users; and policy makers knowledgeable about the nation's highway system. The representatives were drawn from the public and private sectors at the national, state, and local levels.

This initial report will address in varying degrees several of the forum's outcome recommendations. These are:

- Congress should authorize and provide long-term funding for the appropriate Federal agencies to develop a *national road weather research, development, and applications program*, to improve the application of weather information for highway safety and operations.
- DOT/FHWA and NOAA, working with state DOTs, should establish a national road weather and road condition data collection, processing, and dissemination infrastructure to improve the safety and efficiency of the roadway system.
- NOAA/NWS, commercial weather providers, and weather information users should work cooperatively to improve the observation system, develop and improve forecasts, and enhance the delivery of information and services on road weather.
- Federal and state DOTs should train the road management community to more effectively integrate weather into the decision process. In addition, the atmospheric science community, particularly academia, should develop course curricula focusing on road weather science and engineering.
- DOT/FHWA should provide incentives for vehicle manufacturers and highway engineers to raise public and private sector demand for in-vehicle road weather information.

The National Academy of Sciences' Board on Atmospheric Sciences and Climate (BASC) and Transportation Research Board (TRB) developed the report, *Where the Weather Meets the Road--A Research Agenda for Improving Road Weather Services*, which was released on January 16, 2004, The BASC report endorses the WIST Report results and calls for the Federal government to establish a multiyear national road weather research program, led by the FHWA, to bring together the weather and surface transportation research communities. The report also calls for the development of an overarching, multiagency-coordinated WIST implementation program. Other recommendations this initial report will address in varying degrees are:

- Take advantage of existing observation networks and databases.
- Improve the existing observation system.
- Maximize utility and quality of road weather information.
- Improve prediction and warning of weather-influenced hazards that rapidly impede roadway use.
- Improve empirical and numerical modeling techniques to account for both the roadway atmosphere interface and the surrounding environment.
- Improve accuracy and resolution of road weather forecast products supporting both tactical and strategic decision making.
- Establish a focused, coordinated national road weather research program.
- Improve education and training of road weather information users.

Then, in August 2004, acting on guidance from the ICMSSR, the OFCM established the Working Group for Weather Information for Surface Transportation (WG/WIST) to develop both a WIST Research and Development (R&D) Plan and a WIST Implementation Plan. The ICMSSR guidance was to have the WG/WIST ensure that all weather support needs across the six surface transportation sectors--roadway, railway, transit, marine transportation, pipeline systems, and airport ground operations—were considered during the development of the R&D and Implementation Plans. Each agency that is participating in the WG/WIST share the common goal to identify the most pressing research needs facing the Federal WIST community as it strives to increase the safety, efficiency, and mobility of our Nation's surface transportation systems and to recommend a strategy that will eventually satisfy those needs.

On Wednesday, July 20, 2005, the FHWA Administrator Ms. Mary Peters, and the National Oceanic and Atmospheric Administration (NOAA) Administrator, Vice Admiral Conrad Lautenbacher, Jr., USN (Ret), signed a Memorandum of Understanding (MOU) that strengthens the working relationship between the two administrations. This will have a long-lasting benefit to the Road Weather Management program, forming a foundation upon which FHWA and NOAA (especially the National Weather Service) will be able to build integrated solutions that combine the best in weather services with the latest transportation applications.

Appendix D

Aviation Weather Program Activities – A Possible Model for WIST?

In 1995, a study committee of the National Research Council called for coordinated federal action to improve weather services for aviation users and strengthen the R&D base required for sustained improvement. The framework for an invigorated and coordinated national effort in aviation weather was established in the 1997 National Aviation Weather Program Strategic Plan. This document identified strategic elements and defined the roles and missions of participating Federal agencies with respect to those elements, while delegating implementation of the plan to the agencies and their university and industry partners. A second tier of coordination was established by National Aviation Weather Initiatives in 1999. Both of these documents were prepared by the Joint Action Group for Aviation Weather and approved by the National Aviation Weather Program Council.

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

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

In 2003, the midpoint in the original 10-year effort—a mid-course assessment was conducted and the results provided both cause to celebrate and cause to renew and reenergize efforts to reduce the weather-related risks to aviation safety. Celebrate, because real progress is being made. The analyses confirm much anecdotal evidence that the coordinated efforts and diverse partnerships that constitute the national aviation weather program initiatives are making a real difference in accident rates. The investments in research and development (R&D) and implementation of products, services, and systems are paying off. But the overall program goal has not been reached. The program must sustain efforts so effectively started, to continue to see downward trends in aviation weather-related mishaps. A national safety goal that is within reach could slip away. The assessment reports where trouble spots remain and points to ways to overcome them, while furthering the work that has carried the program toward success.

The aviation weather research program shows how coordinated efforts and diverse partnerships within a national program can make a real difference in accident rates. The coordinated and focused investments in research and development (R&D) and implementation of products, services, and systems can produce real results in reducing weather-related mishaps or crashes. The WG/WIST is studying the National Aviation Weather Program to learn from its strengths and leverage on going aviation related research to see where it might benefit the surface transportation and weather community as they strive to reduce surface transportation weather-related deaths, injuries, and lost productivity.