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draft

Meeting the Challenges of Adverse Weather:
A Blueprint for Road Weather Research

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1.0 Introduction

The surface transportation system is dramatically affected by changes in weather. Common experience shows that even relatively light rainfall – when coinciding with congestion or an incident – can bring traffic in an entire metropolitan area to a crawl. In 1999, more than 1.3 million automobile crashes and more than 6,000 fatalities occurred under adverse weather conditions at the surface – where people drive.[1]

A comprehensive program of research will solve the serious problems brought about by adverse weather conditions.

There are solutions to the serious consequences of adverse weather. Access to accurate and timely weather information can dramatically improve the safety, reliability, and productivity of the nation's surface transportation system. The vision of the Federal Highway Administration (FHWA) is to achieve *anywhere, anytime road weather information* – providing quality real-time and predictive information to transportation managers during and before adverse weather.

To achieve this vision, a comprehensive program of research in both weather and transportation – and in the connections between them – is required. Integration of weather and transportation has been a recognized goal of Intelligent Transportation Systems (ITS) for years. This document outlines the FHWA's Road Weather Research Program (RWRP) Blueprint for achieving that goal. This strategy is guided by the FHWA Strategic Plan, and supports the Agency's goals in safety, mobility, congestion, productivity, security, and environment. The RWRP Blueprint is a 10-year plan to advance the state-of-the-art and the state-of-the-practice in road weather management.

The vision is of anywhere, anytime road weather information that meets the needs of transportation managers.

The following pages walk through the key issues and challenges, always keeping in mind the needs of the public – the ultimate customers. It discusses the requirements of those who manage the transportation system, and summarizes the types of adverse weather that affect the system. It describes the varying geographic environments in which adverse weather occurs and in which transportation managers must manage the system.

This blueprint then lays out priority areas for research, using a framework of scenarios that represent key transportation and weather challenges. Finally it presents a specific research program in which the state-of-the-art and the state-of-the-practice can be cost-effectively advanced within an appropriate management structure.

2.0 Background

Coupling and advancing the sciences of weather and traffic is key to a 21st Century transportation system.

Surface transportation is central to our safety and economy, and understanding the weather is key to an effective transportation system. Fog, rain, snow, icing conditions, temperature extremes, high winds, hurricanes, and electrical storms adversely affect the surface transportation system; these conditions impede traffic, impact the economy, and diminish the public's quality of life.

In 1999, adverse weather conditions were present in an estimated 28 percent of personal vehicle crashes and 19 percent of fatalities.[2] More than 16 percent of large truck crashes occurred on wet, snow-covered, slushy, or icy pavement in 1999.[3]

Adverse weather also has significant economic effects. A one-day highway shutdown because of snow or ice costs a metropolitan area $15 to $76 million in lost time, productivity, and wages.[4] Across 281 metropolitan areas in the United States, weather-related freight shipping delays cost an estimated $3.4 billion in 1999.[5]

The surface transportation system is the nation's primary means of moving people and goods, and roads are its backbone – travel on our highways and streets accounts for more than 97 percent of the miles traveled on the surface system. Yet despite the vital role roads play, little has been invested in research to improve our capacity to reduce weather-related injury, death, and delay. In contrast, substantial research has been conducted to advance aviation safety and operations in adverse weather. This research has produced critical data, predictive services, and decision tools for the public, air traffic controllers, and the military – and has led to considerable reductions in weather-related aviation crashes.

There is a need for a new weather research thrust focused on surface conditions. Surface boundary layer research and analysis encompasses the weather conditions, both observed and predicted, at the surface and within the air column directly above the ground. This weather information, coupled with ITS and scientific advances in transportation engineering and management, will address the needs of a 21st Century surface transportation system.

Implementation of road weather ITS has already achieved striking benefits in local areas.

The benefits of investing in road weather information systems have already begun to be demonstrated in a few specific areas. For example, Maintenance Managers in Idaho reduced crashes by 83 percent, labor hours by 62 percent, and material costs by 83 percent by using road weather sensors to mange the application of anti-icing treatments.[6] In southeastern Tennessee, a fog detection and warning system on a key section of Interstate 75 resulted in the number of fog-related crashes declining from more than 200 between 1973 and 1993, to zero crashes between 1994 and 2002.[7] Based on current data, it is projected that even a one percent reduction in crashes would reduce economic losses by more than $1.3 billion annually.[8]

A more comprehensive, systemic approach to research, through a national, integrated Road Weather Research Program will improve the public's safety, enhance the capacity and reliability of the transportation system, and reduce economic losses resulting from adverse weather.

3.0 A Blueprint for Research

Because the subject of road weather research is complex, this strategy lays out one incremental building block at a time, leading step-by-step to a comprehensive blueprint for research. Who are the customers of the transportation system, and who will benefit from improvements in transportation safety and reliability? Who manages the transportation system, and who will use the products of this research? On which weather conditions and which geographic environments should the research focus? The answers to these questions lead to a framework that ensures research investments are targeted to priority needs.

The Customer

The ultimate customer is the public.

The surface transportation system is deeply woven into the lives of people everywhere; it forms the backbone of everyday life. People are the ultimate customer – those who rely on the transportation system as commuters, tourists, and consumers. Police, fire fighters, school transportation systems, emergency medical service providers, and many others rely on the transportation system to meet vital needs of the public. As consumers and producers, people depend on the ability of manufacturers and freight shippers to bring goods to market in the most efficient manner. A recent report by the Federal Motor Carrier Safety Administration (FMCSA) identified weather as one of the top 10 safety concerns for freight carriers. An FHWA study found that 27 million commercial vehicle hours are lost annually because of weather-related congestion across 281 urbanized areas.[9]

The Managers

The transportation system is operated everyday by a variety of skilled and dedicated "managers," often with little awareness by the general public. These individuals have responsibility for monitoring the system at all times, and for anticipating and responding to situations that may impede the movement of people and goods. In addition to the road and highway system, transportation managers also oversee vital rail, transit, and pipeline networks. The needs of these key players – referred to collectively in this strategy as transportation managers – are the primary targeted "users" of the Road Weather Research Program.

Transportation managers – who are responsible for the movement of people and goods – need new ways to respond to adverse weather conditions.

Traffic Managers – Traffic managers are responsible for the day-to-day operation and management of the road and highway system, and for maintaining safety and traffic flow during incidents, adverse weather, and congestion. They typically monitor numerous sources of data, including weather information, which allows them to respond to varying conditions. Response strategies include changing traffic signal timing patterns, providing information to travelers through overhead dynamic message signs, and coordinating with maintenance and emergency managers, as well as with transit managers.

Maintenance Managers – Maintenance managers are responsible for the day-to-day upkeep of the physical infrastructure. They plow and treat the roads in inclement weather, and fix signs, fill potholes, and ensure lane markings and other traffic control features are in good working order at all times. Maintenance managers have an eye both on the safety of the system and on protecting the public's investment in the infrastructure. Maintenance managers rely heavily on weather information to most effectively treat roads before and during adverse weather, and to manage labor needs and schedules; most maintenance activities, such as lane striping, cannot occur under wet pavement conditions. Construction managers also track weather conditions and seasonal climate shifts to plan highway improvements and new construction. Traditionally, maintenance managers have been the focal point for weather data, and coordination between traffic and emergency managers has been limited.

Integrating ITS and weather information is critical.

Emergency and Public Safety Managers – Emergency managers and public safety officials are responsible for responding to incidents on the transportation system, such as crashes, disabled vehicles, and other potentially life-threatening situations. They are also responsible for coordinating responses to major emergencies such as security threats and major evacuations because of extreme weather conditions like hurricanes. Emergency managers include police, fire, and rescue forces, as well as other local, state, and Federal agencies that may have jurisdiction, such as those responsible for homeland security. While coordination between traffic and emergency managers is critical, it is not yet as seamless as technology might allow because of the sheer number of agencies involved and institutional complexities.

In addition to scientific advances, better coordination among transportation managers is needed.

Weather Information Managers – In the weather community, weather information managers provide information to the public and to transportation managers. The complexities of weather require that managers collect and analyze measurements of rain, snow, sleet, fog, and severe and tropical storms. They also need to provide oversight for the calibration and validation of measurements, and develop computer models to localize, predict, and track weather events. Improved measurement and research products are required to ensure that the weather information needed by surface transportation managers is available.

The Weather

Transportation managers operate under a multitude of weather conditions that exist over the course of time. While these conditions may not occur on a daily basis, they are predictable and they occur with enough frequency and magnitude that they warrant a response strategy. The following is a summary of weather conditions where research will provide significant benefit.

Rain, snow, fog, ice, hurricanes, and extreme temperatures dramatically affect the operation of the system.

Rain – Rain ranges from light mists to downpours and, from a traffic management perspective, includes the time following rain when wet pavement conditions exist. Rain affects surface transportation by reducing visibility and changing pavement surface conditions; rain also impedes maintenance activities.

Snow – Snow is a hazard to the driving public. Snow accumulations on frozen pavement form slick pavement conditions. Heavy snow accumulations require snow removal operations, reduction in the number of lanes, or, in some areas, seasonal road closures.

Ice – Ice on roads can result from precipitation in the form of freezing rain from wet pavements that freeze over time as temperatures fall. Icy conditions are extremely hazardous because of reductions in friction on the pavement causing slick road conditions. Unlike snowy conditions where a driver can typically see accumulation, ice can form instantly on the pavement in highly localized areas, with little awareness by drivers.

Fog – While fog can exist anywhere between three feet and 1,000 feet above the ground, from a surface transportation perspective, fog is only an issue when it is low to the ground and visibility is reduced. Under these conditions, massive crashes can and have taken place, producing tragic scenes of death, injury, and property damage.

While extreme weather is not a daily occurrence, it is predictable and responses can be planned.

Tropical Storms and Hurricanes – Tropical storms and hurricanes are characterized by wind speeds from 39 to well over 100 miles per hour (mph) and torrential rains. The accurate prediction of tropical storms and hurricanes is critical to the safety of millions of people who live in coastal areas. The evacuation of people and the response during and after these storms is an enormous undertaking that involves traffic, emergency, and maintenance managers. The science of evacuation, from a transportation perspective, is similar whether the need is caused by a natural weather-related disaster or by a human-induced security-related threat or incident.

Heat – Extreme temperatures that deviate significantly from average seasonal ground-level and near-ground-level values, such as extreme heat, can affect the surface transportation system. Extreme heat and lack of wind compound air pollution in metropolitan areas, directly impacting regional air quality.

The Geographic Environments

Adverse weather requires different response strategies across different geographic environments.

Transportation managers regularly deal with a variety of weather conditions, and they do so within a variety of environments. The variation in geographic environments and the types of weather that occur there directly feed the types of information that managers need in order to respond most effectively. Moreover, the types of transportation systems, the management capacity in place, and the challenges confronting transportation and weather information providers vary across geographic regions. And, of course, different metropolitan areas have different weather conditions and different levels of ITS infrastructure based on their geographic locations. To enable a structured research approach, the following four environments are considered.

Metropolitan – Metropolitan areas are the dense urban and suburban areas where most of the population of the United States lives. These areas often have highway congestion, and most metropolitan governments have made substantial investments in ITS. Metropolitan areas are also where most air quality problems exist.

The amount of ITS infrastructure also varies from place to place, which directly impacts detection and response strategies.

Rural – The rural environment generally encompasses those areas falling outside of metropolitan areas. Their transportation networks are typically characterized by long distances, high speeds, and a lack of ITS infrastructure. During crashes and other incidents – caused by adverse weather or not – emergency response times are often greater than in urbanized areas.

Coastal – Coastal areas encompass the regions in the country most often affected by tropical storms, hurricanes, and storm surges. They include the Atlantic, Gulf, and Pacific Coasts, and shoreline areas in the Great Lakes region. Coastal areas are most often where evacuations need to occur, either because of tropical and severe storms, as frequently experienced in the eastern United States, or mud slides, which are more common in the western United States.

Airports and Ports – Airports and ports, for the purposes of this blueprint, refer to the land side access necessary to keep the facilities open and operating so that the flow of people and goods are unimpeded. In the case of airports, adverse weather directly impacts the ability of people and goods to get to the airport, as well as runway pavement conditions. In the case of ports and other intermodal facilities, adverse weather directly impacts the ability of trucks to access the highway system.

4.0 Research Challenges

Weather prediction models were developed for the air, not the ground.

Accurate and cost-effective, *anywhere, anytime road weather information*, based on quality predictive and real-time information, is essential to meet the needs of transportation managers during various weather conditions, and within different geographical environments. Achieving this will enable transportation managers to take the appropriate actions and management strategies that alleviate weather impacts. Reaching this goal will require the active involvement of a range of participants in both the transportation and weather communities. The commitment of local and regional transportation agencies is needed to incorporate weather information and ITS into their management and maintenance operations. And the weather community needs to identify existing and potential data and predictions that have meaning to surface transportation managers. A strong research program is required involving both the transportation and weather communities.

The Challenge for Weather Research

Like most people, transportation system managers currently rely on weather forecasts to make everyday decisions. These forecasts are usually communicated via television and radio stations, based on data from the National Weather Service (NWS). The NWS predicts the weather based on complex computer models that require measurements from weather sensors throughout the country and around the world.

Higher resolution spatial and temporal forecasts and nowcasts are needed at the boundary layer.

The primary weather research problem related to surface transportation is that current prediction models were developed for aviation purposes and therefore address atmospheric conditions above the surface boundary layer. They do not predict weather conditions on the surface, where pavement freezes, or in the surface boundary layer (three meters or less) directly above the surface, where people drive and where adverse conditions – such as fog – may pose a hazard. A new program of enabling research is needed, focused on weather conditions within the surface boundary layer.

The needed research includes more sophisticated advanced weather observation and forecasting systems to enable surface transportation managers and users to address weather-related risks. Higher spatial and temporal resolution forecasts and nowcasts are needed to better predict key weather conditions in a range of operating environments. Surface forecasts of rain, sleet, or snow; icing conditions; and hurricanes must be updated several times a day with a high degree of reliability. Data are required to forecast the existence of fog, at car or cab height, its density, duration, and rate of dissipation. Improved understanding of the dynamics of high winds, wild fires, and flash floods is required to manage transportation systems. The necessary spatial scale is micro-dimensional: predictions are needed for roads measured in hundreds of square yards or, for a bridge or causeway, hundreds of square feet.

The Challenge for Transportation Research

On the transportation side, advances in response strategies and information delivery systems – based on scientific models and tested applications – are needed across these same conditions and operating environments. The challenge is to integrate advanced transportation and weather systems that can access and seamlessly ingest high-quality weather information on temporal and spatial scales relevant to surface transportation, and provide transportation managers with the resources and techniques necessary to effectively use this information. This coupling of weather and transportation science will enable traffic, maintenance, and emergency managers to improve the safety, reliability, mobility, and productivity of the transportation system.

Research Scenarios

Weather prediction and response advances in one environment will be transferred to the other environments.

The following scenarios are designed to present the most important transportation management practices and related research challenges for the weather and transportation research communities that, if advanced, will achieve the greatest reductions in crashes, injuries, deaths, and economic losses. They are also designed so that the research results from one area can be transferred to the other areas. For example, once the science of fog is understood in the rural environment, that knowledge can be transferred to other environments relatively easily.

Each scenario states the overall problem, the specific issues needing to be addressed, the research requirements for each of the issues, and the anticipated outputs and outcomes of the research.

A. Rain in Metropolitan Areas

Problem:	Congestion during rainy conditions
Target:	Traffic and transit managers
Challenge:	**Research Need:**
• Changing weather conditions	– Improved pavement condition monitoring – Enhanced rain monitoring and prediction capabilities
• More frequent incidents	– Targeted incident response – Enhanced travel demand management
• Reduced capacity because of changes in driver behavior	– Deeper understanding of driver behavior – Advanced traffic simulation modeling linked to weather models
• Poor traffic control	– Signal timing algorithms – Weather-responsive traffic advisory and control strategies for freeways
• Glare/poor visibility at night	– Improved techniques to reduce glare – In-vehicle information systems
Outputs:	Rain algorithms in traffic controllers tested in three locations Rain-responsive strategies integrated into five transportation centers Rain-responsiveness incorporated into management strategies in all major metro areas
Outcome:	Better system performance during rainy and wet conditions, measured by improved travel time reliability

B. Snow in Rural Areas

Problem:	Loss of mobility under snowy conditions
Target:	Maintenance and traffic managers
Challenge:	**Research Need:**
• Changing weather conditions	– Enhanced snow monitoring and prediction capabilities
• Slick pavements	– Improved pavement condition monitoring and response
• Poor traffic control	– Snow-based advisory, control, and treatment strategies
• Ill-informed drivers	– Targeted pre-trip and en-route driver information
• Poor coordination among managers	– Communications and response protocols
Output:	Measurable integration of weather information and responsive strategies (advisory, control, treatment) across maintenance and traffic operations in 10 states
Outcome:	Greater mobility under snowy conditions, measured by a reduction in time required to restore high level of service

C. Ice in Metropolitan Areas

Problem:	Impaired mobility during icy conditions
Target:	Maintenance and traffic managers
Challenge:	**Research Need:**
• Changing weather conditions	– Enhanced ice monitoring and prediction capabilities
• Slick pavements	– Improved pavement condition monitoring and response
• Poor traffic control	– Advisory, control, and treatment strategies for freeways and arterials
• Ill-informed drivers	– Targeted pre-trip and en-route driver information
• Poor coordination among managers	– Communications and response protocols
Outputs:	Ice/snow algorithms in traffic controllers tested in three locations Ice-responsive strategies integrated into five transportation operations centers Integrated weather, road condition, and response information conveyed to travelers (e.g., 511) in five metropolitan areas
Outcome:	Better system performance during icy conditions, measured by improved travel time reliability

D. Tropical Storms and Hurricanes in Coastal Areas

Problem:	Emergency response during tropical storms or hurricanes
Target:	Emergency and traffic managers
Challenge:	**Research Need:**
• Insufficient prediction capacity	– Enhanced prediction of wind and rain conditions
• Congestion on evacuation routes	– Development of evacuation-based traffic management models and tools – Guidance on counter-flow – Targeted pre-trip and en-route traveler information
• Poor coordination among emergency and traffic managers	– Communications and response protocols
Output:	Evacuation-based models and tools in two locations
Outcome:	Improved emergency preparedness, measured by managers' use and understanding of models, tools, and protocols

E. Fog in Rural Areas

Problem:	Crashes under foggy conditions
Target:	Traffic managers
Challenge:	**Research Need:**
• Poor visibility	– Enhanced fog prediction and monitoring capabilities (i.e., expanding from spot-based to route-based capability) – In-vehicle information systems
• Increased speed variance	– Improved analysis of driver behavior – Enhanced traffic monitoring and response strategies
Output:	Pilot systems in five locations
Outcome:	Fewer fog-related crashes

F. Ice in Airport and Port Ground Operations

Problem:	Loss of productivity during icy conditions
Target:	Airport and port maintenance and traffic managers
Challenge:	**Research Need:**
• Insufficient specificity of weather conditions	– Enhanced ice monitoring and prediction capabilities
• Delays because of ground maintenance requirements	– Improved pavement condition monitoring, and response strategies
• Communications and coordination	– Enhanced communications and coordination protocols among maintenance and traffic managers from both airports and ports, as well as metropolitan and rural maintenance and traffic managers
Output:	Model deployments at both one airport and one port
Outcome:	Greater productivity during icy conditions, measured by reduced delay in cargo transfers

G. Heat in Metropolitan Areas

Problem:	Air quality degradation
Target:	Traffic and transit managers
Challenge:	**Research Need:**
• Changing weather conditions	– Improved integration of weather prediction and air quality prediction capabilities
• Poor traffic control	– Advanced parking management
• Excessive vehicle emissions	– Improved demand management
• Poor coordination among managers	– Enhanced coordination among traffic, transit, weather information, and environmental managers
Output:	Showcase integrated strategies in one metropolitan area
Outcome:	Improved response to air quality concerns, measured by managers use and understanding of models, tools, and protocols

5.0 A Comprehensive Research Program

The seven scenarios described above provide a framework for transportation and weather researchers to address multiple gaps in knowledge and technology concurrently. Research findings and products developed under each scenario will be applied to similar research questions in other scenarios, contributing to the overall progress of the Road Weather Research Program. This success will advance the state-of-the-practice in managing the transportation system, and ultimately contribute to improved outcomes in terms of lives saved, injuries avoided, and reduced economic losses. As evidenced by the range of research needs highlighted for each scenario, a full spectrum of research activities is required, including basic and applied research, information and technology transfer, and development of common architecture and standards.

Basic Research

Basic and applied research are the building blocks for advancing the state-of-the-art.

Basic research refers to investigating and resolving the fundamental science questions behind the combination of weather and transportation. On the weather side, basic research is needed to obtain and interpret near-term time horizons and enhanced resolution at the surface. Expanded and innovative weather monitoring is required to collect such data, and existing weather models need to be further developed and refined so that they cover and can provide information at the surface and within the boundary layer, on the most appropriate spatial and temporal scales. On the transportation side, basic ITS research is required to better understand driver behavior under various adverse weather conditions (e.g., the relationship between speed and volume under various weather conditions), and to develop advanced transportation simulation algorithms that incorporate weather and respond to such behavior. Advanced decision-support tools that will most effectively integrate traffic and weather information also need to be developed.

Applied Research

Applied research refers to the use of basic research findings in the field for testing and evaluation. This may include research products, measurement techniques, decision-support tools, or traffic control algorithms. Once developed, these advanced systems will be tested and evaluated in multiple contexts, using the framework of scenarios described above. Pilot studies will be conducted and their results will identify further basic and applied research needs, or be transferred to practitioners.

Technology Transfer

Technology transfer advances the state-of-the-practice.

Historically, there has been little coordination between the weather and surface transportation communities. While this gap in information and resource sharing is changing, weather information and products exist today that are not yet widely used by transportation managers. There is need to establish an aggressive program of information and technology transfer to enable transportation managers to access existing data and decision-support tools, and to facilitate the rapid deployment of best practices as they are developed. The Road Weather Research Program will work with existing technology transfer programs, and where needed, develop supplemental education and training programs to enhance the skills and capacities of transportation managers and users on the most effective use of road weather information.

Architecture and Standards

Open, integrated architectures and non-proprietary standards will ensure technical compatibility.

Architecture and standards refer to the way in which data and information flow between and among technical devices and systems. In order to fully incorporate road weather management into day-to-day operations, the integration between transportation and weather architectures needs to occur. This will allow data to be integrated and accessed by transportation and weather professionals across institutional and regional lines. The National ITS Architecture currently includes limited weather data requirements within its 32 ITS User Services. They include weather requirements for traveler information, in-vehicle route guidance, traffic control and maintenance, and construction operations. However, ITS standards for meteorological services need to be defined and, as products and systems emerge from the Road Weather Research Program, enhancements to the National ITS Architecture will be necessary.

The accuracy of weather forecasts and nowcasts is governed by the adequacy of the measurements and information used to model the behavior of weather. Measurement standards defining temperature, precipitation, fog, and communication of other post-processed information that cross jurisdictional lines must be defined and implemented. As the weather community better defines a weather architecture (e.g., reshaping Advanced Weather Information Processing Systems), it provides the opportunity to link to the National ITS Architecture and create seamless data flows.

These four areas: Basic Research, Applied Research, Technology Transfer, and Architecture and Standards – when applied to the seven scenarios identified above – make up the Program's comprehensive approach to research. Table 1.0 summarizes this research approach.

Table 1.0 Road Weather Research Program Summary

			Weather and Transportation Research Needs			
Geographic Environments	**Weather Scenario (Transportation Goal)**	**User Group**	**Basic**	**Applied**	**Technology Transfer**	**Architecture and Standards**
Metropolitan	Rain (Congestion)	Traffic Managers	X	X		
	Ice (Mobility)	Maintenance Mangers			X	X
	Heat (Environment)	Traffic Managers	X	X	X	
Rural	Snow (Mobility)	Maintenance Managers	X	X	X	
	Fog (Safety)	Traffic Managers	X	X	X	X
Coastal/Causeways	Tropical Storms/ Hurricanes (Security)	Emergency Managers		X	X	X
		Traffic Managers	X	X	X	X
Airports and Ports – Intermodal Ground Transport	Ice (Productivity)	Port and Airport Traffic Managers		X	X	X
		Port & Airport Maintenance Managers			X	X

Risks and Challenges

Insufficient computing power and complex institutional relationships can be overcome with a strong program.

The research strategy outlined above will require sustained effort and investment. The research issues range from simple to very complex and challenging; some key hurdles will need to be addressed to better inform transportation decision-makers in real time. The first hurdle is the current limitation on computing power. Current computing power is insufficient to implement the use of boundary layer analysis for large geographical areas. A second major challenge is the distributed nature of transportation – individual transportation agencies manage and operate systems independently, without common standards or architecture, and often with different objectives and procedures for system management. This decentralized decision-making structure poses institutional challenges for data sharing and coordinated management of the larger transportation network. A third challenge is the lack of strong institutional structures for coordination and information sharing between the transportation and weather communities. This partnership is beginning to develop, and has the potential to foster productive institutional collaboration for both communities. The Road Weather Research Program can address these risks and challenges by strategically focusing its research investments, engaging a range of transportation managers and stakeholders, undertaking a strong program of education and technology transfer, and promoting communication and collaboration between the weather and transportation communities.

6.0 Research Management Plan

It is imperative that research be coordinated across both weather and transportation communities.

Research in both the transportation and weather communities is multi-faceted, and ever advancing. The challenge for the Road Weather Research Program is to take full advantage of the research findings and technological advances achieved by both the weather and transportation communities, while strategically focusing on research that enables transportation decision-makers to make the best use of the evolving body of knowledge.

The FHWA will manage the Road Weather Research Program. However, as demonstrated by the range of research needs identified above, this effort will require a strong multidisciplinary and interdisciplinary approach, involving both the transportation and weather communities. Within the Department of Transportation

(DOT), the Program will work with other key offices, such as those involved in ITS, operations, and safety, to identify weather-related information needs and research priorities, and to provide information about weather data and decision tools that integrate weather and transportation.

Beyond the DOT, the FHWA will partner with the National Oceanic and Atmospheric Administration (NOAA), especially the National Weather Service and the Office of the Federal Coordinator for Meteorology (OFCM). Together these partners will tap the knowledge and perspectives of their in-house experts, transportation agencies at the state and local levels, other Federal partners, academic and industry researchers, the business community, freight carriers, and the traveling public.

Steering Committee

A strong Steering Committee will ensure multi-disciplinary collaboration.

To assist the Program in identifying key research needs, a multi-disciplinary Steering Committee will be established. The Steering Committee will include representatives from each Federal partner, as well as representatives of the weather and transportation research communities, transportation user groups, and stakeholders. The Steering Committee will provide strategic oversight and support to the Program Manager in the following areas:

- Identifying gaps in existing knowledge, data, and analysis, and resulting research needs;
- Guiding the development of annual research action plans, consistent with program resources;
- Providing expert knowledge and user perspectives on the adoption of open architectures, seamless measurement, and product standards;
- Coordinating research products, data, and technologies;
- Guiding the direction of technology dissemination, training, and public information campaigns to promote effective deployment of advanced weather information systems among transportation managers and users of the system; and
- Developing performance measures and evaluation protocols to ensure continuous improvement in the Road Weather Research Program.

The Road Weather Research Program Manager will be responsible for establishing and staffing the Steering Committee, and for the implementation of the Program and its annual research plan.

Resources

To accomplish this plan in 10 years will take investments of $20 million a year.

This blueprint describes a systematic approach to research that will develop the knowledge and tools necessary to create an effective road weather management system. Specific research activities for each scenario discussed in Section 5.0 will be selected by the Program Manager based on the resources available and with expert input from the Steering Committee and user communities. The pace of progress in this effort will be dependent on the level of resources invested. An investment of about $20 million annually over 10 years is required to achieve the outputs and outcomes proposed in the seven scenarios. Overall, this level of investment would enable significant research products to be developed and disseminated to support the development of an advanced road weather management system nationwide.

7.0 Summary

This program will bring direct benefits to the public's safety and the economy.

The experience of local transportation managers who have invested in ITS and road weather management capabilities indicates that a comprehensive, well-coordinated, and effective road weather information management system has the potential to significantly reduce weather-related automobile crashes, injuries, fatalities, and economic losses nationally. An aggressive program of research – involving both the transportation and weather communities – is required to achieve this advanced system and these goals. The Road Weather Research Strategy uses a combined transportation and weather framework to focus research on priority questions related to adverse weather conditions in urban, rural, and coastal areas, as well as in airports and ports. Fully implementing this program will bring direct benefits to public safety and the economy. A one percent reduction in crashes is projected to yield an annual reduction of more than $1.3 billion in economic losses.[10] Further, the existence of more accurate, reliable, and available weather forecasts, nowcasts, and information, will result in far-reaching benefits to the weather community, the nation, and the public at large. Through an active partnership between the FHWA and NOAA, the vision of accurate, cost-effective, *anywhere, anytime road weather information* will be realized.

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[1] Statistics compiled from the DOT National Transportation Safety Administration 2001 Annual Assessment (National Center for Statistics and Analysis), based on the Fatality Analysis Reporting System (FARS) and the National Automotive Sampling System General Estimates System (NASS GES).

[2] NOAA Office of the Federal Coordinator for Meteorology National Needs Assessment Report, *Weather Information for Surface Transportation,* FCM-R18-2002, page ES-2.

[3] Federal Highway Administration *Road Weather Management Program Fact Sheet*, prepared by Mitretek Systems, March 2002, citing the *Fatality Analysis Reporting System (FARS) and Motor Carrier Management Information System (MCMIS) Crash File*.

[4] Federal Highway Administration *Road Weather Management Program Fact Sheet*, prepared by Mitretek Systems, March 2002.

[5] Federal Highway Administration Road Weather Management Program report by Mitretek Systems, *Analysis of Weather Effects on Commercial Vehicle Mobility During Peak Traffic*, October 2002.

[6] Federal Highway Administration *Road Weather Management Program Fact Sheet*, prepared by Mitretek Systems, March 2002.

[7] Federal Highway Administration *Road Weather Management Program Fact Sheet*, prepared by Mitretek Systems, March 2002.

[8] Estimate based on data provided by the National Highway Traffic Safety Administration, U.S. Bureau of Labor Statistics, and the National Institute for Occupational Safety and Health via web site: http://www.nhtsa.dot.gov/people/outreach/employer/WhatCost/summ.html.

[9] Federal Highway Administration Road Weather Management Program report by Mitretek Systems, *Analysis of Weather Effects on Commercial Vehicle Mobility During Peak Traffic*, October 2002.

[10] Estimate based on data provided by the National Highway Traffic Safety Administration, U.S. Bureau of Labor Statistics, and the National Institute for Occupational Safety and Health via web site: http://www.nhtsa.dot.gov/people/outreach/employer/WhatCost/summ.html.