

WHERE THE WEATHER MEETS THE ROAD

A RESEARCH AGENDA FOR IMPROVING ROAD WEATHER SERVICES



On her way to pick up her children from band practice, Karen notes the dark clouds of a thunderstorm rapidly approaching. Meanwhile, computers at a private meteorological service are using data from the National Weather Service (NWS) and the Kansas Department of Transportation to produce a highly specific “pathcast” for the storm, indicating which areas are expected to be affected. Karen’s in-vehicle communication system beeps three times and relays a message that gusty winds and heavy rain, with the possibility of flash flooding, will reach her location within 30 minutes. Concerned about the flooding of a nearby creek, Karen tells the hands-free communication system her destination and requests an alternate route. The system integrates both weather and traffic information and provides an alternate route that allows Karen to circumvent the creek.

Weather significantly affects the safety and capacity of the nation’s roadways. Each year, adverse weather is associated with more than 1.5 million vehicular accidents, which result in about 800,000 injuries and 7,000 fatalities. Inclement weather, such as snow, rain, fog, and ice, can greatly impair roadway conditions. As a result, drivers endure the frustration of more than 500 million hours of weather-related delay annually on highways, affecting both personal lives and economic productivity. Hurricanes and severe snowstorms can cripple regional transportation systems and cause many lost work days for companies and governments.

Too often, people believe that little can be done about the adverse effects of weather on roadway transportation. On the contrary, we are tantalizingly close to providing drivers and traffic managers with the kind of real-time weather and routing information described above in Karen’s scenario, thanks to advances made by both the transportation and meteorological communities. Over the course of the next 15 years, a focused road weather research program that brings these communities together could deliver much better road weather services to the nation, saving lives and reducing injuries while improving efficiency of highway systems.

Where the Weather Meets the Road: A Research Agenda for Improving Road Weather Services, a National Academies report, recommends that the Federal Highway Administration (FHWA) take the lead in creating a coordinated national road weather research program. The program’s main objective would be to bring together the weather and transportation research communities to maximize the use of available information and technologies, identify and support research priorities, and effectively implement new scientific and technological advances.

The Road Weather System of 2020

Recent and anticipated advances in meteorology, roadway technology, and vehicle systems offer great opportunities to improve road weather decision making. Several of the building blocks of the road weather system of the future are in place or under development, and roadway users are already benefiting from some recent advances (see box). Road weather systems could advance very quickly—

probably within the next 15 years—if we could bring existing technologies together.

The road weather system of 2020 envisioned in the report would include a **robust new observation and communication “infostructure”** that will make information available to roadway users where and when they need it. This infostructure overlays the roadway infrastructure and would include: a data collection network, such as sensors embedded in the roadway and video monitoring devices at key

Signs of Progress

Dynamic Message Signs (DMS) are silent messengers strategically placed along highways to disseminate time-sensitive information to travelers on traffic flow rates, weather conditions, road closures, and alternate routes. Although this technology has been used for many years, today’s signs can now display real-time information received from a remote location. Drivers pay close attention to these signs, but it is not yet understood how drivers actually respond to the messages.

Vehicle Telematics include a variety of in-vehicle information and communication technologies and services. For example, since 1997, General Motors’ OnStar technology has offered drivers the ability to contact live, knowledgeable advisors for assistance if broken down, lost, or otherwise in need of service or information. Other companies are developing similar technology; there could be as many as 12 million telematics users by 2008. Advances in this field hold promise for improving how weather and traffic information is communicated to drivers.

Intelligent Transportation Systems (ITS), a major focus of the last decade, seek to take existing detection, computer, and communication technologies and apply in them in an integrated way to increase the safety and efficacy of road transportation. For example, in Minneapolis-St. Paul, real-time data from freeway traffic counters are input into freeway capacity algorithms which, in turn, automatically regulate traffic lights at entry ramps to improve traffic flow.

511 is a single telephone number designated by the Federal Communications Commission in July 2000 that will ultimately connect callers to traffic, weather, and road condition information that can be obtained as they travel through different states.

Specific road weather websites have been developed by several states and private firms that display real-time weather, road condition, and traffic information, including pavement temperature, air temperature, wind direction and speed, dew point, precipitation, pavement condition, and subsurface temperatures.

Sensors embedded in the road surface now relay weather, road condition, and traffic data to maintenance personnel and traffic managers. These data can be used to make forecasts, for example, about when road temperatures will reach the freezing point. In some locations, automatic de-icing devices are coupled with the temperature sensors so the devices will spray an anti-icing chemical on the road when it reaches freezing and water is present.



points; a telecommunication system; and traffic management centers that receive and work with the data and then disseminate information to users. The infostructure would take advantage of advances in sensor technology, information technology, GPS, data management, computing, and geographical information systems, among others.

Important decisions—such as when to slow down, when to salt roads for snow and ice, and when to pour or not to pour concrete—would be supported by “end-to-end” **model-based tools to support decisions** that integrate several elements: real-time observations of current weather, traffic, and road conditions; numerical weather predictions; models of traffic flow given observed conditions; and rules of practice.

Cars and trucks of the future will be able to detect and respond to road weather conditions with ease and could stay in constant communication with weather information providers, traffic control centers, and other vehicles. These **smart vehicles** will inform drivers immediately of poor road conditions and of any obstacles ahead, with access to tools that determine optimum routes.

High costs of controlling snow and ice on roadways demand taking the guess work out of winter maintenance decisions. **Enhanced roadway maintenance** will be able to provide highly targeted weather information and decision support models that codify best practices and include cost-benefit analyses. Prototypes of this sort of decision support tool are already being developed.

New highway construction has decreased markedly, yet the demand for roadway capacity continues to increase. Roadway operators are challenged to manage traffic with ever increasing efficiency, which is made even more difficult in the event of severe weather. **Enhanced traffic and emergency management** will utilize traffic simulation models that dynamically forecast how traffic will most likely respond to weather, construction, accidents, and other road closures.

Journey to the Future

This vision of the road weather system of the future can be achieved only by addressing a number of gaps in existing knowledge and technology. These gaps reflect, at least in part, the lack of integration between surface transportation and meteorological



research and development activities. Therefore, the committee recommends that a focused and coordinated national road weather research program be established to provide leadership and overarching direction for the road weather community.

Transportation research and management are highly decentralized and largely implemented by states; meteorological research and operations are spread across several federal laboratories, universities, and research centers. The private sector has provided many of the targeted road weather services to date; its role will likely expand in the future. Centralized leadership at the federal level is essential in integrating these resources, setting research priorities, administering grants, providing a central repository for research findings, ensuring accountability, and fostering the transfer of new knowledge and technology to operational practice.

The report recommends that the FHWA have the lead role in the national road weather research program, with NOAA as a key partner. Long-term dedicated funding for road weather research sufficient to achieve the program’s goals should be established as new funding within the FHWA. Based on an assessment of unmet needs and costs for comparable research activities, the report estimates the research program will require on the order of \$25 million per year for 15 years.

As a framework for this program, the report recommends the following five key research and development foci:

- ◆ a robust, integrated observational network and data management system specifically designed to meet the needs of enhanced road weather research and operational capabilities;

- ◆ a coordinated research effort to increase understanding of road weather phenomena and develop options for increasing safety, mobility, and efficiency of the nation's roadways during all types of weather;
- ◆ improved modeling capabilities and forecast tools designed to provide relevant, useful information to those who build, maintain, operate, and use the nation's roadways;
- ◆ multiple mechanisms for communicating road weather information to the range of users in ways that support better informed decision making; and
- ◆ an infrastructure that takes advantage of new technologies to monitor and predict road weather conditions and then effectively convey road weather information to end users.

The report makes many detailed recommendations on structuring and implementing a national road weather research program. Of particular note are recommendations to:

Establish Regional Centers. The report recommends establishing regional research centers in order to foster the development of new technologies and their implementation on the roadways, and to facilitate interaction between federal, state and local governments, the private sector, and academia. Because regions share the same road weather challenges, regional centers are preferable to either individual state programs or a single national center.

Create National Demonstration Corridors. As a means to demonstrate the effectiveness of road weather improvements and facilitate the implementation of research results, the report recommends establishing national demonstration corridors along two U.S. interstate highways, one running north-south and one running east-west. These interstates should traverse areas with diverse climate conditions, topography, and geography in order address a wide range of road weather conditions within the demonstration corridor. A major objective for these corridors should be for adjacent states to work together to provide a seamless stream of road weather information to users.

This report brief was prepared by the National Research Council based on the committee's report. For more information, contact the National Research Council's Board on Atmospheric Sciences and Climate at (202) 334-3512, or the Transportation Research Board at (202) 334-2934. *Where the Weather Meets the Road* is available from the National Academies Press, 500 Fifth Street, NW, Washington, DC 20001; 800-624-6242 or 202-334-3313 (in the Washington area); www.nap.edu.



Committee on Weather Research for Surface Transportation: **John Snow** (*Chair*), University of Oklahoma; **Elizabeth Carter**, WeatherExtreme, LLC; **Brad Colman**, National Weather Service; **Dennis Christiansen**, Texas A&M University; **Paul DeLannoy**, Environment Canada; **Francis Francois**, American Association of State Highway and Transportation Officials (ret.); **George Frederick**, Vaisala, Inc.; **Frances Holt**, NOAA's National Environmental Satellite, Data, and Information Service; **Margaret A. LeMone**, National Center for Atmospheric Research; **Curt Pape**, Minnesota Department of Transportation; **Leland Smithson**, American Association of State Highway and Transportation Officials; **Daniel Stock**, American Transportation Research Institute (through April 2003); **Richard Wagoner**, National Center for Atmospheric Research; **Amanda Staudt** (*Study Director*), Board on Atmospheric Sciences and Climate.

Permission granted to reproduce this brief in its entirety with no additions or alterations. Photos by Amanda Staudt, Curt Pape, and the California Department of Transportation.