Heavy rain, snow, ice, dust, fog, and other adverse weather conditions all cause significant effects on roadway safety, mobility, and economic productivity. Over the last decade, weather contributed to nearly 21 percent of all vehicle crashes. On average, nearly 6,000 people are killed and more than 445,000 are injured in weather-related crashes each year. Further, adverse weather causes about 25 percent of all nonrecurring delays, costing the freight industry roughly $3.4 billion and $9.5 billion overall each year for just 85 urban areas alone.

The Federal Highway Administration’s Weather-Savvy Roads initiative directly addresses issues caused by weather impacts on the transportation system by promoting two innovative road weather management solutions: Pathfinder and Integrating Mobile Observations (IMO). Pathfinder provides a step-by-step process for building relationships with partners to share forecasts and road conditions, and then provides consistent messaging to travelers. IMO involves enhanced data collection from agency fleet vehicles to improve awareness of road conditions.

“Pathfinder and IMO are two innovative solutions that enable transportation agencies to better manage the highway system under adverse weather, ultimately saving lives and keeping traffic moving safely and smoothly,” says Mark Kehrli, director of transportation operations at FHWA.

FHWA promoted the Weather-Savvy Roads initiative through round four of its Every Day Counts (EDC-4) program (2017–2018). State and local agencies may choose to adopt Pathfinder, IMO, or both to more proactively manage their roadway networks ahead of and during weather events.

Two Innovative Solutions
Pathfinder represents a collaborative effort between a State department of transportation, the National Weather Service, and any contracted weather service providers. Specifically, Pathfinder provides an 8-step process to build on existing practices that share forecasts and road conditions among partners to share forecasts and road conditions, and then provides consistent messaging to travelers. IMO involves enhanced data collection from agency fleet vehicles to improve awareness of road conditions.

Implementing Pathfinder involves a multistep process of assessing the types of information to share and how to share it before, during, and after high-impact weather events. The goal is to provide the public with consistent and actionable messages on potential impacts on the transportation network.

IMO promotes the collection of weather, road, and vehicle data from agency fleet vehicles to improve situational awareness of road conditions. This initiative builds on the vehicle-based technologies that most States have already implemented in...
their vehicle fleets, including automatic vehicle location and real-time communications. IMO enhancements involve ancillary sensors that collect data on weather and road conditions such as air pressure, air and surface temperatures, spreader rate and materials, windshield wiper status and rate, and relative humidity.

Enhanced data from IMO provide maintenance managers with a detailed view of local conditions, as well as the location of assets along the highway network. This information can support maintenance and operations decisionmaking related to road weather forecasts, end-of-shift reporting, material management, traveler information, and performance management.

**Benefits and Costs**

Pathfinder and IMO each improve highway safety, mobility, and productivity. However, the benefits and costs of each vary depending on the nature of implementation.

Pathfinder benefits can include enhanced decisionmaking and better informed travelers, resulting from consistent and targeted traveler information messaging. “We find that the traveling public often looks to multiple sources for weather information,” says Jeff Williams, weather program manager at the Utah Department of Transportation (UDOT). “If the traveling public receives the same message about storm impacts no matter the source, we see the traveling public react.”

Pathfinder deployments also include the potential for reduced vehicle miles traveled, improved maintenance operations with less motorist impedance, and increased overall safety. The costs associated with Pathfinder are minimal and primarily associated with the amount of time staff at the agency and weather service provider must spend to conduct collaborative activities.

For IMO deployment, a key benefit is material savings from the reduced salt and sand usage. Real-time information about road conditions and fleet vehicle locations assists maintenance staff in making more informed decisions about material applications, which may enable agencies to use fewer materials. In addition, agencies may experience increased efficiencies including improved reporting, reduced time spent relaying information, better situational awareness, and reduced resources needed to respond to emergencies. More comprehensive and accurate real-time information about resource consumption provides agencies with the data needed for decisionmaking. Over time, IMO deployments could also lead to reduced equipment usage and lower legal costs from small tort claims.

Typical IMO costs may include automatic vehicle location and sensor equipment; communications services; development and implementation of systems to gather, interpret, and present data for action; and systems operations and maintenance. The ways an agency may choose to deploy IMO will affect upfront costs. For example, instrumenting a greater number of vehicles may result in economy-of-scale discounts. Costs vary based on the number and types of sensors mounted on each vehicle. Long-term costs of industrial-grade, commercial off-the-shelf components will be lower than a custom-designed system. Staff training is another cost consideration, particularly when implementing new, unfamiliar systems or for unique, custom-built systems that require specialized skills to design, build, and operate.

**Pathfinder in Practice**

State and local agencies have deployed Pathfinder processes in a variety of ways to best suit the needs of each agency. Currently, 21 States are working to adopt Pathfinder. Pathfinder has proven successful for many State and local agencies, as pilot deployments have demonstrated in Utah and Truckee, CA.

UDOT created the Pathfinder process to improve road weather messaging during the 2002 Winter Olympics. The agency has continued the process because of the successful relationships and outcomes.

UDOT employs Pathfinder processes to ensure that the public uses road weather messages to make
The Wyoming Department of Transportation, with the help of a commercial forecasting service, collaborates with the National Weather Service to create and disseminate Pathfinder videos to help communicate anticipated weather-related travel impacts to the public. Photo: Wyoming DOT.

This is a screenshot of the National Weather Service weather story for Utah showing a map of snow impacts and listing the specific impacts to major roadways. Photo: UDOT.

appropriate travel decisions in advance. Improved relationships between UDOT, the National Weather Service, and a private-sector weather provider have helped to sync messages from media and weather outlets on road weather impacts and increase public trust in UDOT traveler information systems. Travelers who take actionable steps based on the information they receive will likely experience safer trips and overall improved mobility.

The benefits of Utah’s Pathfinder process include enhanced decision-making and better informed travelers through consistent and targeted traveler information messaging, as well as improved maintenance and increased safety. UDOT and the National Weather Service conducted a survey of 800 travelers following two winter weather events in 2013. Results showed that 97 percent of travelers gathered information about the event with 83 percent of individuals using multiple sources of information. Of the respondents, 66 percent modified their travel plans by: changing their schedule (62 percent), changing the route (26 percent), not traveling (13 percent), or using transit (6 percent). UDOT also reported improved snowplow effectiveness, reduction in costs, and improvement in efficiency because of shared resources among agencies.

At a local level, Truckee, CA, is located on I-80 near the Nevada border with a population that greatly increases on weekends and holidays during the summer and winter seasons for recreational purposes such as skiing, snowboarding, and water-based activities. Extreme vehicle and truck crowding occurs during winter closures on the interstate. Weather events include large amounts of snow and heavy rain with a high risk of flooding. Town officials recognize that severe weather events that may cause dangerous driving conditions require one cohesive message, coordinated with other agencies, to ensure safe mobility, and reduced confusion.

Using Pathfinder principles, the town built direct relationships with the National Weather Service to obtain and discuss severe weather forecasts, warnings, and watches ahead of major weather events. At the same time, Truckee fostered relationships with District 3 of the California Department of Transportation (Caltrans) for insights related to I-80 operations and traffic. These relationships are essential to Truckee’s road operations decisions and communications with travelers. In addition, relationships with law enforcement and emergency responders help coordinate operations and public messaging during severe weather events. Working across these agencies with Pathfinder ensures the...
The Minnesota Department of Transportation installed this on-board mobile data computer in a snowplow truck cab as part of the agency’s IMO deployment. 
Photo: MnDOT.

The public receives consistent, meaningful messages for making smart decisions. Truckee noted the following Pathfinder benefits:

- **Enhanced weather knowledge.** A direct relationship and communication with the National Weather Service has improved Truckee’s knowledge of expected severe weather significantly, enabling the town to more effectively prepare its response.
- **Expanded public information and outreach.** Providing critical information to the public through Truckee’s web portal about road conditions has improved operations, increased safety, and enhanced public trust.
- **Improved efficiency and effectiveness of road operations.** Enhanced weather knowledge and public outreach have improved operations. The town can better allocate resources, mitigate known problem areas, operate more effectively with fewer motorists on the roads, reduce environmental impacts, and enhance safety through generally better road conditions year-round.
- **Increased public relations.** Providing complete information to the public and stakeholders, including trouble spots and real-time road operations, has significantly increased public relations between the town, the traveling public, and other entities.

### Expanding Use of Pathfinder

The FHWA Road Weather Management team has helped to support a number of agencies interested in deploying Pathfinder, often by facilitating an onsite workshop or peer exchange for interested stakeholders to learn more. Several agencies have initiated a Pathfinder pilot as a result of these efforts, including Kansas, Minnesota, and Nebraska.

The Minnesota Department of Transportation (MnDOT) Pathfinder pilot occurred during the 2017–2018 winter season. The agency activated Pathfinder every time the National Weather Service issued a blizzard warning. The pilot also included implementing a National Weather Service chat room with instant messaging service for MnDOT to enable staff to better monitor updates and briefings with MnDOT, the National Weather Service, and the MnDOT weather service provider.

The collaboration facilitated weather updates and consistent messages for the public. The pilot was successful in its first season given the increased collaboration, improved working relationships, and enhancements to the Pathfinder program. The pilot generated a variety of lessons learned for involved stakeholders to expand and improve the process for the subsequent winter season. For example, to ensure all key individuals are included in Pathfinder briefings, MnDOT will create an email distribution list.

### IMO Success Stories

Thirty-five State and local agencies have deployed IMO, including 24 States that have committed to adopting IMO as part of EDC-4. For example, Minnesota and West Des Moines, IA, have each deployed IMO technologies and demonstrated success.

MnDOT has been incrementally implementing an IMO program with a goal to improve existing processes and enhance the capabilities of mobile data acquisition systems. MnDOT instrumented 478 heavy duty trucks, 20 light duty trucks, and 5 mowers over 3 phases of IMO deployment. MnDOT collected data from the vehicles and external sensors using customized software and equipment, then transmitted the data to servers via cellular and dedicated short range communications. MnDOT staff used the data for road weather conditions, end-of-shift reports, material management, traveler information, and maintenance decision support.

MnDOT has benefited from its IMO efforts through the experience and involvement with the various technologies. Internal data sharing and reporting helped the agency to achieve savings on material costs and to understand how the savings result from specific maintenance actions. Specifically, plow operators input the amount of chemical applied by route at the end of each shift, which they gather from the automatic vehicle location screen. MnDOT maintenance managers then compare
recommended versus applied chemical amounts. Other available data include speed while applying chemicals, average precipitation, end-of-shift reports, material usage by route, and sander status reports. These data support MnDOT’s salt sustainability effort to track material usage in a more efficient manner. MnDOT also noted that end-of-shift reports have resulted in labor cost savings and a grassroots support for IMO technology.

At a local level, West Des Moines is a suburban community of 68,000 residents with 800 lane miles (1,290 kilometers) of pavement. Located at an interstate crossroads, the daytime population increases to more than 150,000 people. The extensive commuter traffic, combined with winter weather conditions in the area, demands effective road weather management strategies.

The West Des Moines Public Services Department leverages available resources to deploy new technologies and equipment to improve its winter maintenance operations. Efforts have included deploying infrared sensors for assessing pavement slickness, automatic vehicle location and mobile sensors on plows and other agency vehicles, software for route optimization, and a maintenance decision support system (MDSS) for material type and application determination.

West Des Moines’ savings from reduced salt and material use (while providing the same level of service) far exceeded the costs of the technology. Specifically, the agency has reduced chloride application by 30 percent, saving about $150,000 annually. The city’s MDSS uses the available real-time road weather conditions and fleet vehicle locations to provide recommendations on material type, application rates, and timing for maintenance staff to make better decisions.

Route optimization has increased efficiency, reducing the time needed to clear various areas, fuel consumption, and wear and tear on the plow truck fleet. These efficiencies result in about $50,000 savings per year and the ability to do more with less. In addition, with increased data available for review after a winter weather event, agency staff can examine the storm’s progression using road weather data such as friction data and photos from a road weather information system, and then compare it to the operational strategy and results. In this way, the city can modify and enhance its strategy for truck placement, material type, and timing of material application to better meet level-of-service goals for future winter weather events.

**Toolkit and More Resources**

For agencies interested in more information about deploying Pathfinder or IMO in their region, FHWA has created a Weather-Savvy Roads Resource Toolkit. The toolkit houses fact sheets, case studies, early adopter reports, videos, guidance documents, and other implementation resources in a central location at https://go.usa.gov/xnSgY. Specific resources that agencies may find helpful include the Pathfinder implementation guide, Collaboration Across the Road Weather Enterprise: The Pathfinder Project (FHWA-HOP-16-086), available at https://ops.fhwa.dot.gov/publications/fhwaop16086/index.htm, and the IMO early adopter final reports, which are available at https://collaboration.fhwa.dot.gov/dot/fhwa/RWGX/SiteAssets/resources-early-imo.aspx.

“It’s really important to have the ability to monitor weather events and their potential impact on roads,” says Randy Graham, deputy chief of the Science and Technology Infusion Division at National Weather Service’s Central Region, “Because weather is one of the only things that has an impact on the entire road system at one time.”

**Paul Pisano** recently retired as the team leader of the Road Weather and Work Zone Management Team in the FHWA Office of Transportation Operations. He holds B.S. and M.S. degrees in civil engineering from the University of Maryland.

For more information, see https://go.usa.gov/xnSgY or contact Roemer Alfelor of FHWA’s Road Weather Management Program at 202-366-9242 or roemer.alfelor@dot.gov.