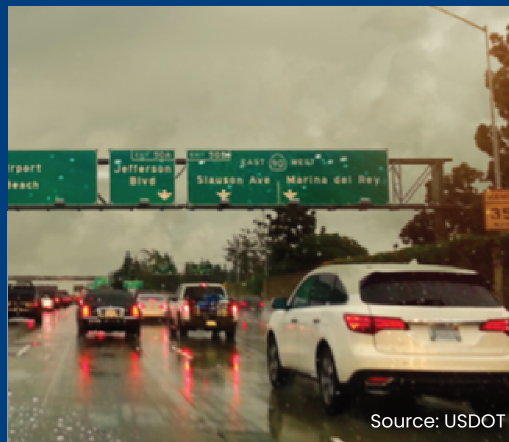
ITS DEPLOYMENT EVALUATION

EXECUTIVE BRIEFING



Source: USDOT

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Rural Road Weather Management Systems

Highlights

- Automated weather alert system (Wx-TINFO) recommended response actions for winter weather maintenance activities resulted in user delay cost savings of 25 to 67 percent.
- Automated web-based management tool (Salt Dashboard) saved Iowa DOT $2.7 million per year by helping efficiently utilize salt resources.
- Integrating Mobile Observations (IMO) smartphone app saved Michigan DOT an estimated $680,000 annually due to staff time saved by automatic system reporting.

This briefing is based on past evaluation data contained in the ITS Benefits, Costs and Lessons Learned databases at: www.itskrs.its.dot.gov. The databases are maintained by the U.S. DOT's ITS JPO Evaluation Program to support informed decision making regarding ITS investments.

U.S. Department of Transportation
Intelligent Transportation Systems
Joint Program Office

Introduction

Weather-related crashes are defined as crashes that occur in adverse weather (e.g., rain, sleet, snow, fog, severe crosswinds, or blowing snow/sand/debris) or on slick pavement (e.g., wet pavement, snowy/slushy pavement, or icy pavement). On average, more than 5,000 road user deaths and 418,000 injuries occur annually as a result of weather-related crashes. These events are also responsible for significant delays and economic impacts. Even though winter road maintenance accounts for roughly 20 percent of state DOT maintenance budgets, motorists continue to endure more than 500 million hours of delay each year as a result of fog, snow, and ice, and weather-related delays cost trucking companies $2.2 billion to $3.5 billion annually.[1,2,3,4]

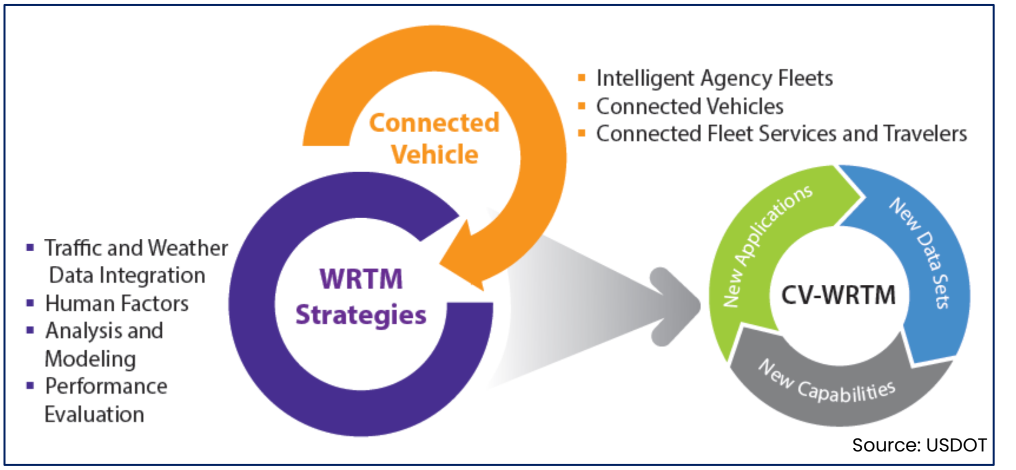
Recent advancements in automated vehicle technology and mobile data communications have enabled Weather Responsive Traffic Management (WRTM) systems to leverage real-time connectivity between both infrastructure and vehicles, and among vehicles themselves to expand coverage and improve the quality, quantity, and timeliness of road-weather data available to commuters and truckers traveling on corridors subject to adverse weather.

Introduction (continued)

Figure 1 depicts how current WRTM strategies can leverage data from intelligent agency fleets, connected vehicles, third-party fleet services, and travelers to enable a new design space: Connected Vehicles for Weather Responsive Traffic Management (CV-WRTM) applications. Although most currently available automated vehicle systems have not yet proven their capability to both detect and operate in adverse weather conditions, the data collected from onboard sensors and performance monitoring systems can be shared with other road users and infrastructure owner operators to enable new CV-WRTM strategies.

Recently, the U.S. DOT Every Day Counts (EDC) initiative and Weather-Savvy Roads effort have supported two distinct strategies to advance the development of connected vehicle applications and WRTM strategies, as shown in Figure 1.

Figure 1: Evolution of WRTM Strategies



1. **Pathfinder** is a collaborative effort between the National Weather Service (NWS), transportation agencies, and support contractors to provide road weather information by sharing and translating weather forecasts into consistent transportation impact statements for the public.
2. **Integrating Mobile Observations (IMO)** involves collecting weather, road condition, and native data from government fleet vehicles' ancillary sensors. These data provide maintenance managers with an extremely detailed view of weather and road conditions as well as asset locations along the highway network. This information supports road weather management maintenance and operations decision-making, and public traveler information systems.[5]

The overall goal of these programs is to help agencies manage road systems and keep travelers informed during severe weather events that can have significant impacts on traveler safety, mobility, and productivity.

Benefits

The data below derived from several evaluation projects demonstrate how connected-vehicle systems and data sharing applications can be combined to benefit state agency maintenance programs and roadway travelers.

Mobility

- In Waterloo, Canada, a simulation study modeled the impacts of a weather-responsive traffic signal timing system and estimated a 20 percent reduction in intersection delay (2020-01470).
- In Michigan, a WRTM system (Wx-TINFO) provided automated weather alerts and supported agency response actions to reduce traveler delay costs by 25 to 67 percent during National Weather Service advisories and warnings (2017-01145).

WRTM strategies can improve safety and mobility, reduce the environmental impact of maintenance materials, and decrease operational costs.

Productivity

- In Iowa, an automated web-based management tool (Salt Dashboard) designed to help winter maintenance decision makers efficiently utilize salt resources saved the Iowa DOT $2.7 million per year (2019-01418).
- In Wyoming, a road condition reporting application designed to connect Wyoming DOT staff to a central system, and automate several operational tasks including data logging and reporting of traveler information updates, saved the agency more than one person-year of labor costs (2017-01131).
- In Michigan, an IMO smartphone application designed to provide real-time information on the performance and resource consumption of 20 snowplows and 40 light maintenance vehicles saved Michigan DOT (MDOT) an estimated $680,000 annually due to staff time saved by automatic system reporting (2020-01456).
- In Michigan, deployment of a Maintenance Decision Support System (MDSS) that uses data from global positioning systems (GPS) and automatic vehicle location (AVL) equipment installed on 340 fleet vehicles reduced agency salt usage by approximately 25 percent, saving MDOT about $2.1 million per year (2020-01456).

Benefits (continued)

Safety

- Modeling studies show that weather responsive traffic signal systems can reduce rear-end conflicts by 22 percent in moderate traffic and by 43 percent in heavy traffic (2013-00889).
- In Colorado, a weather responsive variable speed limit system reduced winter weather related crashes by 100 percent on a section of highway subject to extreme temperature changes (2014-00894).

TMC's warn travelers of floods.

Costs

Road weather management systems include multiple subsystems. Examples of cost drivers for several subsystem elements are highlighted below.

Roadway Equipment

Intelligent Transportation Systems (ITS) Roadway Equipment represents ITS equipment that is distributed on and along the roadway to support traffic management and monitor roadway conditions.

- **Roadway Weather Information System (RWIS)** (2019-00427)
  RWIS stations allow Transportation Management Center (TMC) operators and maintenance personnel to determine weather conditions for specific roadway segments, and support maintenance deployment and scheduling. They also support traveler functions by combining with traveler information systems to warn drivers of dangerous environmental conditions.
  - **Capital Cost:** $100,000 to $150,000 (estimates exclude costs for power connections and backhaul communication links).
  - **Annual O&M Cost:** $5,000 (costs will vary depending on number and type of additional costs if communication services are leased).
- **Closed-Circuit Television (CCTV)** (2019-00427)
  CCTV cameras in remote areas support TMC operators by enabling them to visually monitor weather and traffic conditions and verify the operation of field equipment such as roadside dynamic message signs and traffic signal systems. CCTV camera data can also be integrated with other road weather reporting systems to enhance traveler information broadcast to the

Costs (continued)

general public. This multi-functionality provides high cost-effectiveness compared to other more focused monitoring devices, such as detector stations.

- **Capital Cost**: $75,000 to $150,000 (assumes cabinet and mounting pole. For more remote locations, power and communication costs will vary significantly).
- **Annual O&M Cost**: $2,000.

Maintenance Vehicle Fleet Management

Automated Vehicle Location (AVL) fleet management applications allow fleet managers to monitor the location of fleet-vehicles at any given time to ascertain progress of field activities. Checks can include ensuring the correct roads are being plowed and that work activity is being performed at correct locations.

- **AVL Onboard Equipment (OBE)** (2019-00431), (2019-00442). Maintenance vehicles such as snowplows can be equipped with onboard systems to track vehicle location and monitor material distribution (such as sand or salt treatments).
  - **Capital Cost**: $3,843 to $15,000 per vehicle (higher cost includes some retrofitting).
  - **Annual O&M Cost**: $472 to $1,000 per vehicle.
- **AVL Fleet Tracking System** (2014-00303). AVL technology platforms can support maintenance vehicle fleets through wireless communications with on-board computers to control in-vehicle devices such as salt-spreaders, proximity switches, pressure sensors, and Radio-frequency identification (RFID) readers. These solutions can collect large amounts of operational data and provide back-end services with specialized reports to meet customer requirements.
  - **Capital Cost**: $164,058 per implementation (includes hardware, software, and labor components for wireless data and voice communications for 256 vehicles).
  - **Annual O&M Cost**: $64,719 to $71,461 (includes warranty, support, and maintenance fee components).

> An average GPS/AVL system costs less than $4,000 to install and requires less than $40 per month in recurring maintenance costs per vehicle.

Best Practices

Road weather management agencies across the country continue to implement innovative RWIS solutions and create awareness among private sector developers on how connected vehicle solutions can be used to improve road weather maintenance operations and traffic management in areas prone to adverse weather. Findings and lessons learned in several states are as follows:

- **Michigan DOT** - Use multiple communication protocols (such as cellular, Wi-Fi, and Dedicated Short-Range Communications (DSRC)) to transfer data from mobile devices, and optimize channel usage based on the Use Case when using connected-vehicle systems to enhance weather observations (2019-00898).
- **Iowa DOT** - Use simple decision tree models instead of complex regression and neural network models to predict winter road weather conditions. Focus on pavement temperature, pavement condition, and bridge temperatures to better support maintenance strategies (2019-00884).

Road weather management systems enhance traveler safety in harsh weather conditions.

Case Study

Interstate 80 (I-80) in southern Wyoming is a major corridor for east/west freight movement and moves more than 32 million tons of freight each year. During winter seasons when wind speeds and wind gusts exceed 30 mi/h and 65 mi/h, respectively, crash rates on I-80 are three to five times as high as summer crash rates, and in recent years, the number of blow-over crashes on this corridor has doubled.

> **Data collected by fleets and roadside equipment in Wyoming give drivers improved traveler information through services like the Wyoming 511 app and CVO portal (CVOP)**
>
> \- Wyoming DOT

In order to address the needs of commercial vehicle operators and improve safety, productivity and mobility, the Wyoming Department of Transportation (WYDOT) developed and deployed a range of ITS services as part

Case Study (continued)

of a Connected Vehicle (CV) Pilot project to support vehicle-to-infrastructure (V2I) and vehicle-to-vehicle (V2V) connectivity by providing drivers with weather advisories, roadside alerts, parking information, and dynamic travel guidance. The overall goal of the pilot project was to improve the situational awareness of drivers that frequently use the corridor and to reduce the number and severity of winter-related incidents (including secondary incidents).

During the CV Pilot project, approximately 402 miles of I-80 were equipped with countermeasures. Approximately 75 roadside units (RSUs) were installed along various sections of I-80 to enable vehicles equipped with onboard units (OBUs) to communicate wirelessly with the RSUs using dedicated short-range communication DSRC radios and exchange information with management centers via backhaul communication networks. Approximately 400 vehicles including a combination of fleet vehicles and commercial trucks equipped with OBUs participated in the deployment. At least 150 of these vehicles were heavy trucks that are regular users of I-80, including 100 WYDOT fleet vehicles, snowplows, and highway patrol vehicles supplemented with mobile weather sensors. The overall cost to implement the system, including equipment and labor over a 3-year period was estimated at $5.76 million (2017-00386).

The following best practices were captured by WYDOT team members:

- **Consider system requirements for data storage and throughput**. Conduct feasibility analysis to assess data storage and throughput requirements. It is important to look at data restrictions and estimated data volumes, and how you will communicate back to the TMC or cloud environment. At highway speeds, contact time for over-the-air software updates is short and off-loading data is a challenge. Trim logged messages and have over-the-air updates be restartable.
- **Ensure bad actors will not get access to the system and the system is trustworthy.** Public sector networks typically do not support IPV6. Plan to continuously upgrade, patch, lock, probe and analyze network security. Evolving security credentials management systems (SCMS) will require flexibility in the development of associated interfaces.
- **Utilize current standards as a part of the system architecture design process.** Embrace SAE J2945, IEEE 1609, and NTCIP standards. Standards can help create a solid deployment effort, simplify technical documentation, and assist with interoperability.

Case Study (continued)

- **Reserve an appropriate amount of time in the schedule to account for test planning and test execution.** Detailed test planning is dependent on many factors including equipment availability, so the development of detailed test plans can be a lengthy process while uncertainties are nailed down.
- **Recognize that leveraging new systems (such as new Android tablets, new onboard units, new GPS system, new DSRC system) can be difficult with complex fleet vehicle operations.** Maintaining an OBU fleet is hard and security obfuscation makes it harder. Ensure vendors have good service agreements with their component vendors and periodically review system designs and integrated elements[6] (2017-00788).

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