Best Practices for Road Weather Management

Version 3.0

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16. Abstract

On average, there are over 6,301,000 vehicle crashes each year. Twenty-four (24) percent of these crashes – approximately 1,511,000 – are weather-related, resulting in 7,130 fatalities and 629,000 injuries. In spite of these statistics, there is a perception that transportation managers can do little about weather. However, three types of mitigation measures may be employed in response to environmental threats: advisory; control; and treatment strategies. Advisory strategies provide information on prevailing and predicted conditions to both transportation managers and motorists. Control strategies alter the state of roadway devices to permit or restrict traffic flow and regulate roadway capacity. Treatment strategies supply resources to roadways to minimize or eliminate weather impacts. Many treatment strategies involve coordination of traffic, maintenance, and emergency management agencies. These road weather management strategies are employed in response to various weather threats including fog, high winds, snow, rain, ice, flooding, tornadoes, hurricanes, and avalanches.

This report contains 27 case studies of systems in 22 states that improve roadway operations under inclement weather conditions. Each case study has six sections including a general description of the system, system components, operational procedures, resulting transportation outcomes, implementation issues, as well as contact information and references. Appendix A is an acronym list.

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Introduction

Weather threatens surface transportation nationwide and impacts roadway safety, mobility, and productivity. Weather affects roadway safety through increased crash risk, as well as exposure to weather-related hazards. Weather impacts roadway mobility by increasing travel time delay, reducing traffic volume throughput and speeds, increasing speed variance (i.e., a measure of speed uniformity), and decreasing roadway capacity (i.e., maximum rate at which vehicles can travel). Weather events influence productivity by disrupting access to road networks, and increasing road operating and maintenance costs.

There is a perception that transportation managers can do little about the average 7,130 fatalities and 629,000 injuries that occur every year during adverse weather conditions. However, three types of road weather management strategies may be employed in response to environmental threats: advisory; control; and treatment strategies. Advisory strategies provide information on prevailing and predicted conditions to both transportation managers and motorists. Control strategies alter the state of roadway devices to permit or restrict traffic flow and regulate roadway capacity. Treatment strategies supply resources to roadways to minimize or eliminate weather impacts. Many treatment strategies involve coordination of traffic, maintenance, and emergency management agencies. These mitigation strategies are employed in response to various weather threats including fog, high winds, snow, rain, ice, flooding, tornadoes, hurricanes, and avalanches.

This report contains 27 case studies of systems in 22 states that improve roadway operations under inclement weather conditions. Each case study has six sections including a general description of the system, system components, operational procedures, resulting transportation outcomes, implementation issues, as well as contact information and references.

Version 2.0 presented 30 case studies from municipal and state transportation agencies. At this point, those solutions are either mainstreamed or have been surpassed by even better solutions. Version 3.0 captures the state-of-the-art, presenting 27 all-new practices that build upon these agencies' previous successes.

Alabama DOT Low Visibility Warning System

In March 1995 a fog-related crash involving 193 vehicles occurred on the seven-mile (11.3 kilometer) Bay Bridge on Interstate 10. This crash prompted the Alabama Department of Transportation (DOT) to deploy a low visibility warning system. The warning system was integrated with a tunnel management system near Mobile, Alabama.

System Components: Six sensors with forward-scatter technology are used to measure visibility distance. The visibility sensors are installed at roughly one-mile (1.6 kilometer) intervals along the bridge. Traffic flow is monitored with a Closed Circuit Television (CCTV) surveillance system. Video from 25 CCTV cameras is displayed on monitors in the Traffic Management Center (TMC). Field sensor data is transmitted to a central computer in the TMC via a fiber optic cable communication system. The computer controls 24 Variable Speed Limit (VSL) signs and five Dynamic Message Signs (DMS), which are used to display advisories or regulations to motorists.

In 2008, a system upgrade was performed to the fog system. These upgrades included updating devices, improving the method of communication with these devices by going from a point-to-point system to Ethernet, and the addition of Radar Vehicle Detection (RVD) devices every one-third of a mile along the Bayway.

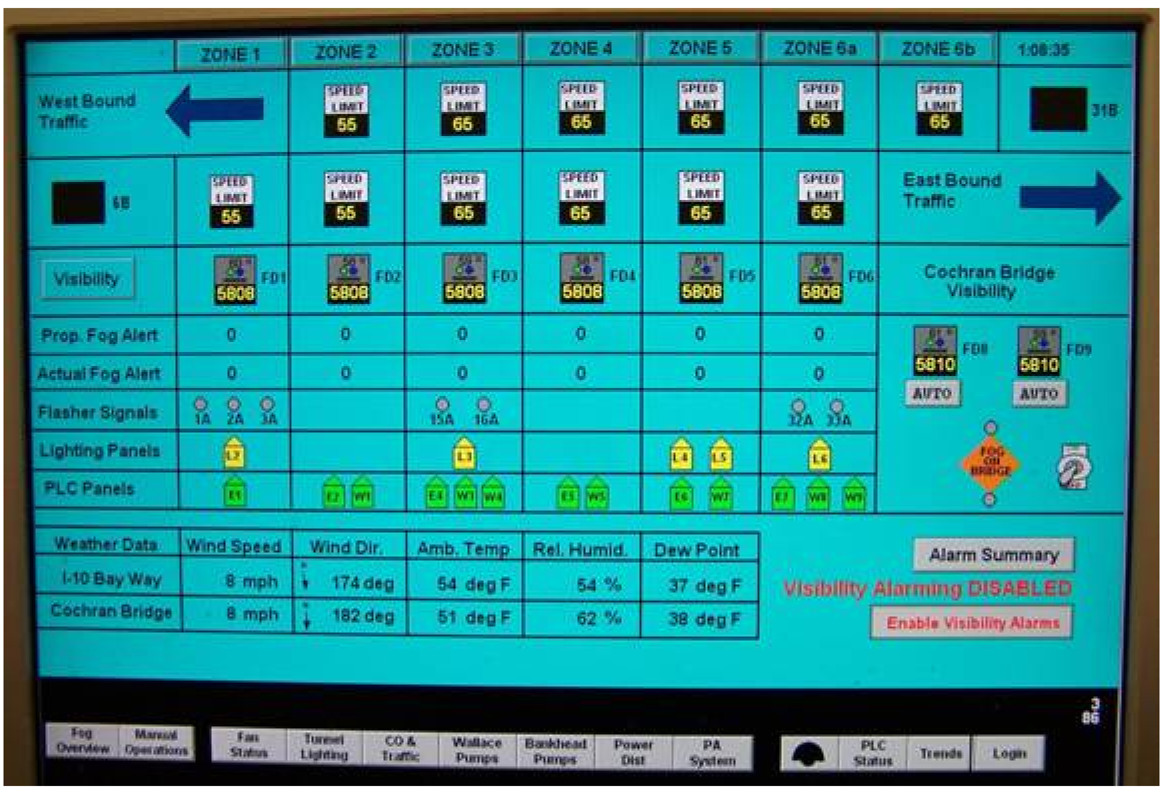


Figure AL-1. Screen Shot of Low Visibility Warning System.

System Operations: At least two Automated Transportation System (ATS) Operators staff the TMC twenty-four hours a day. When fog is observed via CCTV, ATS Operators consult the central computer, which displays visibility sensor measurements by zone. The warning system is divided into six zones which can operate independently. Depending on visibility conditions in each zone, operators may display messages on DMS and alter speed limits with VSL signs (as shown in the Table AL-1, Visibility Warning System Strategies).

Table AL-1. Low Visibility Warning System Strategies.

Visibility Distance	Advisories on DMS	Other Strategies
Less than 900 feet (274.3 meters)	"FOG WARNING"	Speed limit at 65 mph (104.5 kph)
Less than 660 feet (201.2 meters)	"FOG" alternating with "SLOW, USE LOW BEAMS"	"55 MPH" (88.4 kph) on VSL signs "TRUCKS KEEP RIGHT" on DMS
Less than 450 feet (137.2 meters)	"FOG" alternating with "SLOW, USE LOW BEAMS"	"45 MPH" (72.4 kph) on VSL signs "TRUCKS KEEP RIGHT" on DMS
Less than 280 feet (85.3 meters)	"DENSE FOG" alternating with "SLOW, USE LOW BEAMS"	"35 MPH" (56.3 kph) on VSL signs "TRUCKS KEEP RIGHT" on DMS Street lighting extinguished
Less than 175 feet (53.3 meters)	I-10 CLOSED, KEEP RIGHT, EXIT	½ MILE Road Closure by Highway Patrol

When the speed limit is reduced, notices are automatically faxed to the DOT Division Office, the Highway Patrol and local law enforcement agencies in Mobile and neighboring jurisdictions (i.e., Daphne and Spanish Ford). If necessary, ATS Operators request that the Highway Patrol utilize vehicle guidance to further reduce traffic speeds. During vehicle guidance operations a patrol vehicle with flashing lights leads traffic across the bridge at a safe speed.

Transportation Outcome(s): Although labor-intensive, the warning system has improved safety by reducing average speed and minimizing crash risk in low visibility conditions.

Implementation Issues: The original system design included a vehicle detection subsystem, backscatter visibility sensors, and automated activation of signs. Bridge deck construction precluded the installation of inductive loop detectors and vibration prevented the use of microwave vehicle detectors. Thus, the vehicle detection subsystem had to be eliminated. Visibility sensors with backscatter technology were deployed along the bridge in the fall of 1999. However, problems with accuracy and reliability caused the DOT to replace them with forward-scatter visibility sensors in 2000.

The original George C. Wallace tunnel control room was modified to incorporate monitoring and control functions for the warning system, which began operating in September 2000. By 2004, control of the warning system was transferred to the new Traffic Management Center.

Contact(s):

- David M. Johnson, Alabama DOT, ATS Center Manager, 251-432-4069, johnsond@dot.state.al.us
- Daniel Driskell, Alabama DOT, Acting Traffic Engineer, 251-470-8231, driskelld@dot.state.al.us

- Lee Reach, Alabama DOT, Division Maintenance Engineer, 251-470-8230, reachl@dot.state.al.us

Reference(s):

- Schreiner, C., “State of the Practice and Review of the Literature: Survey of Fog Countermeasures Planned or in Use by Other States,” Virginia Tech Research Council, October 2000.
- U.S. DOT, “Mobile, Alabama Fog Detection System,” *2001 Intelligent Transportation Systems (ITS) Projects Book*, FHWA, ITS Joint Program Office.

Keywords: fog, visibility, low visibility warning system, tunnel management system, speed management, traffic management, law enforcement, traveler information, advisory strategy, traffic control, control strategy, bridge, lighting, high-profile vehicles, motorist warning system, closed circuit television (CCTV), dynamic message sign (DMS), institutional issues, speed, safety

Alaska DOT&PF Temperature Data Probe Program

The Alaska Department of Transportation and Public Facilities (ADOT&PF) has developed an effective seasonal weight restriction program that uses temperature data probe (TDP) profiles as one tool to issue fact-based weight restriction notices. TDP sensors deployed at strategic locations provide a vertical temperature profile in the six foot layer below the pavement surface. The TDP sites are polled periodically, data are collected and loaded into an Oracle relational database, and then are available under *Alaska's Road Weather (RWIS) and Temperature Data Profiles TDPs for M&O* on the ADOT&PF internal web page <web.dot.state.ak.us> and the Road Weather Information System (RWIS) public web site <http://roadweather.alaska.gov>.

Weight limitations during the spring thaw restrict the Maximum Allowable Axle or Axle Group Weights to less than the typical summer/winter loads. These restrictions help prevent pavement damage, avoid higher road maintenance costs, and limit vehicle wear and tear. Additionally, timely weight restriction notices allow commercial trucking the opportunity to plan their work schedules and minimize the impacts of hauling less than full loads.

The regional maintenance engineers base these temporary weight restrictions on the downward thaw progression; inputs to their decision process include:

- Past weather – includes the past week and conditions from the previous fall such as amount of rainfall
- National Weather Service forecasts – solar insolation, temperatures, precipitation
- Local maintenance and operations staff experience – including local TDP measurements
- Roadway pavement structure – roadbed materials, soil characteristics, pavement age, and drainage capabilities
- Site observations – standing water, water seepage through pavement cracks, precipitation, and remaining snow cover

The weight restriction decision-making process involves multiple ADOT&PF work centers. Communication among state, local government, and commercial trucking agencies provide for an effective restriction notice distribution process.

System Components: The temperature probe program started with the Northern Region Fairbanks Research Section more that 20 years ago. In 1990 there was a coordinated effort to install statewide permanent data recorders and collect telemetry. The TDP program continues with new installations as construction projects and funding allows. There are over 75 sites around the state where TDP are installed in the road section.

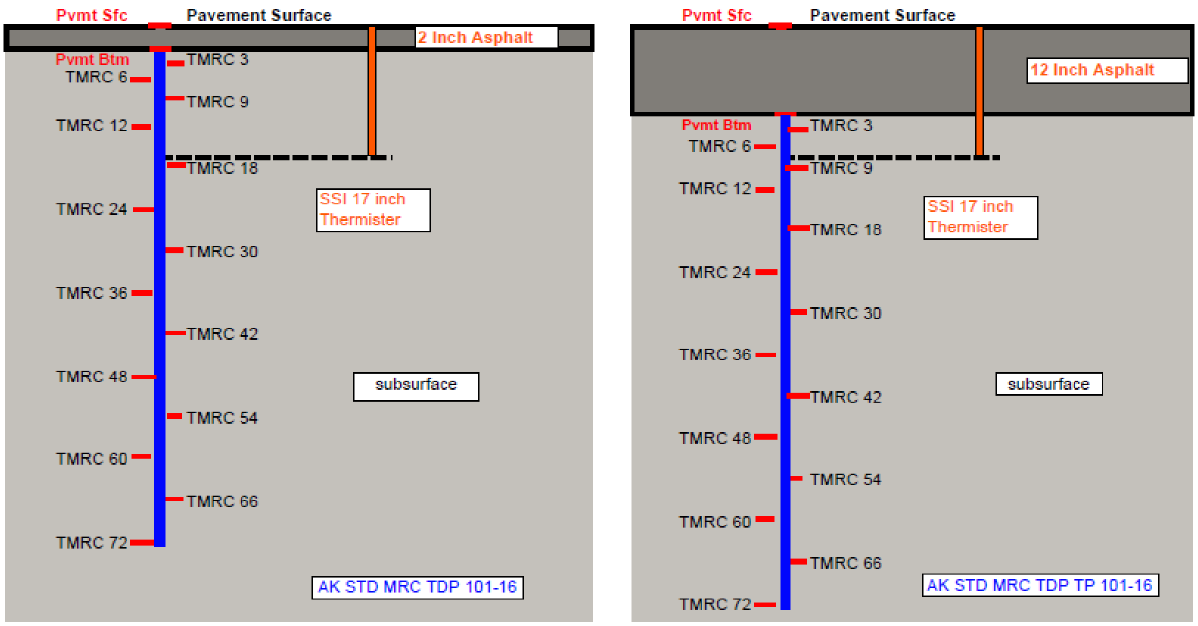
Figure AK-1. Thermistor string and temperature probe casing.

Figure AK-2. Boring hole for temperature probe.

Figure AK-3. Top sensor on a wire lead.

The probes have been manufactured by Measurement Research Corporation (MRC). MRC is only providing a limited number of TDP units, so ADOT&PF is diligently searching for another supplier for future years. Each probe has a lead-in data cable and a 6-foot thermistor string, one-inch diameter, encased in an epoxy resin. Figure AK-1 shows the 6-foot thermistor string with the top "pig-tail" thermistor featured in the inset. The MRC probe is installed vertically through the pavement in a hole, which is normally drilled through the shoulder of the road, as shown in Figure AK-2. The hole is back-filled with sand and capped with asphalt pavement.

There are 16 thermistors in the MRC probe. The top sensor is on a wire lead and is placed within 1 inch of the pavement surface (Figure AK-3). The second sensor is positioned at the bottom of the pavement, no matter the depth. Sensors #3 through #6 are spaced 3 inches apart, sensors #7 through #16 are spaced 6 inches apart, so sensor #16 is positioned 72 inches below the bottom of the pavement. Figure AK-4 diagrams the vertical thermistor spacing. The older MRC probes co-located with a RWIS site do not have the pavement surface thermistor. In these cases, the RWIS pavement sensor (Vaisala's FP 2000, ThermoScan1000, or DST 111) temperature is used for this top reading and is reported in the online TDP profiles.



The graph shows the contrast of different pavement thickness and levels of temperature measured by the MRC probe (installed at the bottom of pavement) vs. the SSI 17 inch probe (installed from pavement surface). Note: Drawing is not to scale.

Figure AK-4. Diagram of the vertical thermistor spacing.

System Operations: Regional maintenance engineers try to issue weight restrictions three days prior to altering existing weight restrictions to allow truck operators to plan their work schedules and to minimize the impacts. The regional Maintenance and Operations staff e-mails the restriction notices to a pre-determined list of parties, which includes ADOT&PF regions and districts, trucking firms, ADOT&PF Measurement Standards and Commercial Vehicle Enforcement (MS/CVE), the military, Alaska State Troopers, local law enforcement, and local transportation authorities. The local Maintenance and Operations staff post the restriction signs along the roadway.

Weight Restrictions - Ketchikan Area

Category: Public Notices
Sub-Category: Weight Restrictions
Publish Date: 03/21/2006

Department: Transportation & Public Facilities
Location: Ketchikan
Coastal District: N/A

Body of Notice:

Effective 03/21/06, 10:00 a.m. and until further notice the following emergency weight restrictions are in effect for listed state maintained highways and roads in Ketchikan area.

This weight restriction applies to trucks of 10,000 lbs. or more.

State roads listed: 50% of legal load
D-2 Loop, D1-Loop, No. Point Higgens Spur, Potter, South Point Higgins, Wood Road, Powerhouse, North Tongass (end of pavement to Waterfall II), Shoup Street, Revilla Road, Cranberry, Knudsen Cove, North Point Higgins, Pond Reef, Shoreline, Sunset, Roosevelt Drive.

State roads listed: 75% of legal load
North and South Tongass from City Limits to end of road.
North City Limits start at mile 4418 N. Tongass.
South City Limits start at mile 1 S. Tongass.

Legal axle loads are:
Single Axles 20,000 lbs. 50%=10,000
2-axle tandem 38,000 lbs. 50%=19,000
3-axle group 42,000 lbs. 50%=21,000

For specific information, call Nick Farstad, Ketchikan Maintenance Station at (907) 225-2513.

Figure AK-5. Example of a posted weight restriction.

Local transportation authorities use the State restrictions to help develop local restrictions. In many cases, they adopt the ADOT&PF restrictions for adjacent roads in their service areas. Local Maintenance and Operations staff may also issue weight restrictions on State roads in their local area.

MS/CVE posts the weight restrictions on the State of Alaska Online Public Notice web site <http://notes4.state.ak.us/pn> and maintains the commercial weight restrictions on the MSCVE web site:

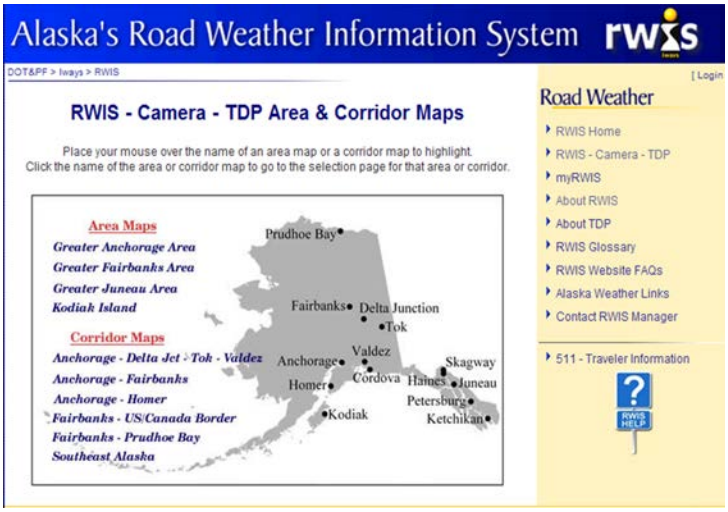


Figure AK-6. Areas and corridors of Alaska with TDP sites.

<http://dot.alaska.gov/mscve/main.cfm?go=weightrestrictions>. Figure AK-5 shows an example of a posted weight restriction. MS/CVE Commercial Vehicles Customer Service Center posts the weight restrictions on FAX-On-Demand (907-348-9876). Stakeholders can also sign up for email and text message notification. MSCVE and the Alaska State Troopers enforce the posted weight restrictions.

TDP data are available on the internal ADOT&PF home page at <http://web.dot.state.ak.us/> under *Alaska's Road Weather (RWIS) and Temperature Data Profiles TDP's for M&O* and on the Road Weather Information System (RWIS) public web site <http:/roadweather.alaska.gov>. Both web applications also include road weather and camera information. On the internal application, Vaisala's proprietary ScanWeb application presents the most recent TDP for each site. There is also an area summary for TDP sites within a given travel corridor.

Figure AK-7. Anchorage-Homer corridor with available TDP sites.

Both web sites offer access to TDP through corridor maps. Figure AK-6 shows the four areas and six corridors that have TDP sites. Passing the cursor over an area/corridor area will highlight the area/corridor on the state map. Clicking on the area/corridor text will display the area/corridor with the available TDP sites. Figure AK-7 shows the Anchorage – Homer corridor with the available TDP sites. Hovering over the TDP site displays the name of the site.

The RWIS web site <http://roadweather.alaska.gov> provides Road Weather, Camera, and TDP information on a single base map. Simply click on TDP at the top of the corridor map to show the available TDP sites for this map area. Select the appropriate TDP site to get to the TDP setup screen. Output formats include both an on-line graphical report and a delimited export file. A pull-down menu also provides an alpha list of available TDP sites. Three time periods are available: 24 hours, 7 days, and 31 days. A calendar function provides an easy date range selection; the earliest data availability is included in the site metadata. TDP data are sorted into three-degree temperature bins for graphical display.

Transportation Outcome(s): A progressive series of roadway weight restrictions become necessary each spring when Alaska's road embankments thaw as temperatures rise from south to north across the state. These spring weight restrictions are necessary to help protect highways from unnecessary damage, help avoid higher road maintenance costs, and limit vehicle wear and tear.

Per the Alaska Regulations, at 17 AAC 25.100 (a), "The Department of Transportation and Public Facilities may prohibit the operation of vehicles upon any highway or may impose restrictions on any aspect of vehicle operation on any highway whenever the highway, in the judgment of the commissioner, may be seriously damaged or destroyed by such operation."

Limitations are therefore imposed from March through June, area by area, and road by road, by restricting the Maximum Allowable Axle or Axle Group Weights to less than typical summer or winter loads. Where a value of "100%" represents the normal legal maximum allowable weight, key paved and unpaved roads are temporarily constrained by public legal notice to restrictions of 85%, 75%, or even 50% of the statutorily defined weights.

Once the thaw process starts at the pavement surface and progresses downward slowly, over a period of days and weeks, moisture content rises and a water-saturated layer of soil generally develops between the uppermost (thawed) zone of pavement and structural fill, and the still-frozen mass of sub grade beneath the thawed layer.

- Trucks and trailers moving heavy cargoes press down atop this constrained system, dramatically increasing the thaw zone's pore pressure. This potentially can cause "quick" foundation conditions, a loss of strength within the granular soil matrix, and can trigger pavement flexure and rutting (soil displacement), constituting significant road damage. The real-time TDP temperature data at various depths, times of day, and dates provides a clear indication of when certain roads across the state are likely to be incapable of supporting heavy wheel loads because of the progressing thaw depth. This is when load limits, restricting vehicle loads to viable non-damaging levels, are posted.

Reasonable thaw progression estimates are possible by observing site-specific conditions reported by experienced maintenance station foremen. Considerations such as a road's drainage and soil characteristic, variable pavement age and structural condition, remaining snow cover, and weather forecasts are all important at each TDP location. The maintenance engineer uses the previous years' archived TDP thaw data and the relative loss of strength from shallow thaw depths to impose load limits. With the return of load-carrying ability within the granular embankment structure in place below the paved (or unpaved) road surface as the thaw gets deeper, load limits are then carefully lifted. Depending on the quality of the roadway's structural regime and moisture content circumstances, load restrictions are usually completely lifted as the thaw depth exceeds 48 inches.

DOT&PF's TDP sensors play an important role in selecting which roads to include in road restriction notices and to what level of restriction to apply at various dates. Alaska's cost-effective TDP system plays a useful and desirable role in providing real-time temperature data for year-round uses, but its spring applications are particularly critical and unparalleled in protecting the state's $10 billion highway infrastructure, while realistically balancing the competing needs of surface transportation, commerce and industrial livelihoods. TDP data are also used for road design and arctic research.

Implementation Issues: The TDP program incorporates two statewide networks, one for TDPs co-located with RWIS sites and one that is comprised of stand-alone installations. The co-located sites are polled hourly by the RWIS servers in Anchorage and Juneau and packaged into a 24 hour TDP data file. The stand-alone sites are polled periodically by the Central Region Highway Data Section (CR/HDS). TDP data are transferred to Juneau where they are loaded to an Oracle relational database at 5:00am, noon, and 5:00pm each day.

Campbell Scientific data loggers (model CR-10X) installed in adjacent roadside cabinets collect the CR/HDS TDP data. The CR/HDS polls the TDP sites via modem periodically, more often in the spring, forwards hourly data files to Juneau for loading into an Oracle relational database. Manual readings can be taken from the remaining older MRC thermistor probes on-site when connected to a hand-held display. Most of the stand-alone TDP sites also have other temperature sensors installed such as ambient air temperature and the reference temperature inside the control cabinet. These additional data elements are also available in the Oracle database.

The MRC probes co-located with RWIS sites are connected to the RWIS remote-processing unit (RPU) computer in adjacent roadside cabinets. Vaisala, the Department's RWIS contractor, maintains the RWIS sites. These sites are equipped with telemetry that ties into the Internet or the State of Alaska wide area network (WAN). At remote locations, wireless radios provide a connection from the RWIS sites to the Internet or WAN. The RWIS servers in Anchorage and Juneau poll these sites at least three times an hour. The RWIS server forwards the daily TDP files to Juneau for loading into the Oracle relational database.

ADOT&PF has several ongoing initiatives to upgrade the RWIS web site and TDP program. These initiatives include moving to a GIS-enabled, Google-like web interface, improving the communications to the CR/HDS TDP data loggers, automate the CR/HDS TDP data polling, and introduce standard TDP profile reports that can be distributed to interested stakeholders automatically.

Contact(s):

- Howard Helkenn, Central Region Traffic Data Manager, 907-269-0876, howard.helkenn@alaska.gov
- Jack Stickel, Transportation Information Group – Division of Program Development, 907-465-6998, jack.stickel@alaska.gov

Reference(s):

- Road Weather Information System (RWIS) public web site <http://roadweather.alaska.gov>
- State of Alaska Online Public Notice web site <http://notes4.state.ak.us/pn>

Keywords: legal maximum allowable weight, maximum allowable axle weights, quick foundation conditions, seasonal weight restrictions, spring weight restrictions, soil temperature profiles, spring thaw, temperature probes, temperature data probes

Arizona DOT DUST Warning System

One of the biggest challenges for road weather management along Interstate 10 (I-10) is dust storms. Currently, in the spring of each year these often unpredictable events wreak havoc on travel along I-10. Dust storms are an important safety concern in the region, especially for out-of-state drivers who are unfamiliar with this phenomenon. These dust storms can reduce visibility to extremely low levels, causing multiple-car accidents.

The Arizona Department of Transportation (ADOT) has developed the Dual Use Safety Technology (DUST) Warning System to help reduce the loss of life, injury, and property damage on rural I-10 in Cochise County between the communities of Bowie and San Simon. The system has been designed to focus on dual challenges:

1. Visibility hazards caused by blowing dust on a sixty mile segment of I-10 between Bowie and the New Mexico Stateline.
2. Unexpected snow and ice in the Texas Canyon area of I-10.

The DUST Warning System provides an early warning and detection for icy conditions in Texas Canyon as well as wind borne dust along I-10 using several Environmental Sensor Stations (ESS) and a comprehensive sensor array. Each ESS site is equipped with a snapshot Closed Caption Television (CCTV) camera to visually confirm any potential low visibility conditions.

System Components: The enabling technologies that are integrated to form the DUST Warning System include:

- Wireless Ethernet Networks - Based on the WIMAX IEEE 802.16 standard, the wireless network solution is integrated to serve as a cost-effective and reliable long-range communications backbone for the DUST Warning System.
- Photovoltaic Cells - Power for the remote telemetry sites are derived from renewable solar energy generated using photovoltaic cells. Initially developed to power satellites, the technology has gained recent widespread acceptance for solar powered remote telemetry and warning applications.
- Anemometers - These devices measure wind speed to predict the potential for on-set of high wind conditions, which may lead to reduced visibility conditions.
- Forward Scatter Visibility Sensors Technology - It uses the forward scatter principle of light in the presence of atmospheric particles to measure the extinction coefficient and visibility. A high-intensity infrared Light Emitting Diode (LED) transmitter is used to illuminate the sensor's

Figure AZ-1. Visibility sensor in ADOT DUST warning system.

scatter volume. This results in a high signal-to-noise ratio and reduces the effects of background light variations. Visibility measurements are possible over a standard range up to more than 10 miles as depicted in Figure AZ-1.

- Light Emitting Diodes - LEDs have been in use as indicators for decades. As the reliability, heat tolerance, brightness and efficiency have increased, LED technology has gained widespread acceptance for application as traffic signal or warning beacon indications.
- CCTV Camera – Each ESS site is equipped with a snapshot CCTV Camera to visually confirm any potential low visibility conditions.

System Operations: The overall concept of operations for the DUST warning system is quite simple. Sensors are used to detect high winds and low visibility conditions. In addition, CCTV cameras will be providing snapshots for visual confirmation of low visibility conditions, so that ADOT and Department of Public Safety (DPS) can make informed decisions regarding roadway closures and detours as needed.

The DUST warning will use Programmable Logic Controllers (PLC) to trigger various warning devices when wind speed thresholds are exceeded or when sensors detect that minimum visibility thresholds are not met at any of the monitored sites. The components of the warning system include:

- The DUST Warning System hardware is connected to the nearby ADOT Dynamic Message Signs (DMS) and is able to post messages from a set of stored DMS messages based on sensor inputs, as seen in Figure AZ-2.
- The DUST Warning System will enable Highway Advisory Radio Service (HARS) and play from a set of up to eight locally stored messages, based on sensor inputs.
- The DUST Warning System is capable of sending sensor alerts to a group of programmable e-mail addresses to alert highway operations and law enforcement staff of high wind and/or low visibility conditions.

Figure AZ-2. Dynamic message sign with warning message.

Transportation Outcome(s): ADOT has implemented the DUST warning system in an effort to reduce the number of crashes on I-10 caused by the limited visibility experienced during certain weather conditions. Instrumentation detects adverse weather conditions and then alerts travelers of high winds and limited visibility. Additionally, the system notifies ADOT operations personnel of these conditions and records certain parameters for future review. Video equipment also assists ADOT personnel to quickly assess field conditions remotely. Although there are additional components located at the Texas Canyon Mountain pass, further west between Benson and Wilcox, that system monitors for snow and ice conditions, but does not trigger any public alerts.

Under certain conditions, alert and informational messages are automatically delivered to the public through a variety of field components. Messages are pre-scripted and vary with instrumentation input. The combination of static and dynamic signing plus the HARS broadcasts present drivers with immediately important and usable information when needed in order to help prevent driver distraction and information overload.

Operational personnel can access data and live video feeds plus receive email notifications. This allows the quick assessment, confirmation, and subsequent sharing of information with law enforcement and New Mexico DOT counterparts. Decisions regarding highway closures and remote traveler notification are expedited and more reliable.

Implementation Issues: ADOT's DUST warning system is not a new technology, but rather a second-generation prototype which expands the capabilities of an older, smaller system. There are issues which should be addressed as the technology evolves and consideration given to deploying similar systems elsewhere. Although not mutually exclusive, these issues can be segregated into administrative and technical areas in nature.

The administrative issues highlighted here could be considered typical in any weather-warning project:

- The Department must commit operating and maintenance funds to sustaining the system, not just the initial cost for installation. Training on how to operate and maintain the system must be reflected in the funding allocated.
- The integration of other measures and stakeholders, and the degree of integration, must be considered. For example, allowing New Mexico DOT to view Arizona weather data is fairly simple via the Internet. However, ensuring than an appropriate and coordinated multi-agency, multi-state response is provided for a large-scale, sustained weather event takes a substantial amount of effort.

Technical issues discovered so far (and others will surely manifest themselves over time) include the following:

- Specifying, procuring, and installing the system requires a team with specialized experience. Using a qualified consultant greatly helps. A warranty period should be included in any agreement as well as training and field shadowing to facilitate the knowledge transfer from the vendor to public sector Department personnel. Vendor technical support should include both hardware and software.
- Determining what data to collect, how to store it, review it, and how long to keep it is quite a significant effort. There has been some discussion that none of the data should be recorded due to potential liability concerns; however, that issue has not been fully resolved within ADOT.
- The initial calibration and set points for parameters takes time to discern. There may be some variability in wind speed versus soil type versus dryness, etc., that can make each site unique from other locations. There is a growing body of knowledge, but in the end the operator will need to adjust the system sensitivity until false alarms are minimized and the alerts delivered to the public are accurate (so dust storm messages are not displayed during a calm day and vice versa).
- The HARS does have serious limitations due to Federal Communications Commission transmission power and frequency assignment restrictions. Although the immediate vicinity may be covered, the signal becomes essentially imperceptible in less than a mile's distance. HARS is not an effective long-distance warning device; it is only good for delivering instructions to travelers in the immediate area. Many question its cost effectiveness.
- Email overload is one of the first observations made by new users, especially before the system set points are dialed in to minimize false alarms. Several users first excited about participating in the new system chose to later unsubscribe from the email warning

distribution list because of the high volume of repetitive warnings. Operations personnel in the field typically do not have access to email, especially after hours. Typically, law enforcement has no interest in receiving automated email messages but rather rely on ADOT notification or personal field observations.

- Sensory instrumentation and subsequent alerts are just snap shots of conditions in the immediate vicinity within a long corridor that in reality may be experiencing a wide variety of conditions. It would be cost prohibitive to place a continuous array of sensors and warning devices along any corridor so any proposed effort should focus on segments of highway where weather-related problems have already been demonstrated. Because this segment of I-10 in southeastern Arizona had a history of crashes and a larger-than-normal number of fatalities due to weather-caused visibility problems, it was deemed an appropriate location for deployment of this technology.
- ADOT has struggled whether to periodically review weather, crash, and system performance data with the goal of validating whether the system is worth the cost. It is noted that both weather events and crashes are highly random in nature and it can be expected to take several years for enough data to be collected to make a meaningful assessment. However, ADOT knows that a single fatality has both a very high emotional as well as financial cost to society. If the Department can reduce the number of crashes then the system cost could be justified in a traditional business sense. It may be difficult to analytically demonstrate a reduction in crashes attributed to this warning system. Nevertheless, system reliability will always be an issue and maintenance programs have real costs that need to be justified so this particular question remains open.
- All involved would do well to remember that a certain portion of the traveling public will either be confused by the warning messages or choose to ignore them and attempt to pass through an area experiencing bad weather while hoping for the best. Current technology will not resolve that challenge.

Contact(s):

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- Bill Harmon, Arizona DOT, Safford District Engineer, 928-432-4919, bharmon@azdot.gov
- Jon Lovell, Arizona DOT, Transportation Engineering Specialist, 602-712-7754.

Reference(s):

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- Severe Weather Warning System Dual Use Safety Technology (DUST) Warning System.

Keywords: Visibility, Snow, Forward Scatter Visibility Sensor, Anemometer, Wind, Dust, CCTV, Dynamic Message Sign, Highway Advisory Radio Service

California DOT Fog Detection and Warning System

California's Great Central Valley suffers from Tule fog. It is a thick ground fog which reduces visibility to one hundred feet or less that settles in the San Joaquin Valley and Sacramento Valley areas of California's Great Central Valley. Tule fog forms during the late autumn and winter (California's rainy season) after the first significant rainfall. This phenomenon is named after the tule grass wetlands (*Tulare's*) of the Central Valley. Accidents caused by the tule fog are the leading cause of weather-related traffic accidents in California.

In response the California Department of Transportation (Caltrans) contracted ICx Transportation to build and integrate a fog detection and warning system along a 13-mile section of the California Highway 99 corridor in the central part of the state. The system was completed in 2009.

California's Central Valley—extending from Bakersfield in the south to Redding in the north—is one of the country's largest agricultural regions. It is also a major transportation corridor, with Interstate 5 and California Highway 99 (CA-99) running through the valley. CA-99 in Fresno in the project area carries more than 100,000 vehicles per day. The region is subject to a particularly dense kind of fog, known as Tule fog, during the winter. In fog season, which runs roughly from November 1 to March 31, Tule fog can form overnight and reduce visibility to less than an eighth of a mile, and in some cases to nearly zero. Drivers along the corridor routinely would continue to drive at unsafe speeds despite the low visibility, which has led to large, multiple-car crashes. In November 2007, Tule fog caused a 108-car pile-up. There were two deaths and nearly forty injuries. The pile-up, which included 18 semi-trailer trucks, extended for nearly a mile and closed CA-99 for over twelve hours. The last vehicle collided ten minutes after the initial crash.

In addition to the threat to life and property, these major pile-ups have an enormous effect on the economy of the Central Valley. In order to reduce the likelihood of future multi-vehicle crashes, District 6 of the Caltrans is implementing a pilot project to automatically detect fog and warn motorists of hazardous conditions. Construction on the Fog Detection and Warning System (FDWS) began in October 2008.

Phase 1 was completed in February 2009 and Phase 2 was completed before the beginning of the 2009–2010 fog season on November 1, 2009. The project covers a thirteen-mile stretch of CA-99 south of Fresno, California.

System Components: The FDWS system consists of visibility sensors, speed detectors and cameras to detect congestion and visibility problems that could affect driver and passenger safety.

Figure CA-1. Sensor array.

The installation is forty percent solar powered and uses both point-to-point and point-to-multipoint wireless radios to provide network connectivity. Local field controllers allow the field equipment to work autonomously if there is a break in communications to the central system.

System Operations: Through intelligence built into the ICx Cameleon™ ITS product, the system alerts motorists automatically of dangerous weather conditions and slow speeds by using changeable message signs (CMS) and highway advisory radio (HAR). The system will soon be incorporated into a 511 traffic web page and telephone system.

Speed detectors have been deployed every quarter of a mile, and fog sensors and CMSs deployed every half mile. Using the data collected from the sensors, the CMSs warn drivers of the presence of fog downstream and instruct them to slow down when they are in dense fog. When slower speeds are detected downstream, the CMSs warn drivers of the slower traffic ahead. HARs, roadside weather stations, cameras and multi-color changeable message signs are included.

The FDWS will use sensors to detect both visibility and speed on CA-99 in the project area. To measure visibility, the team selected the PWD10 forward scatter sensor developed by Vaisala. The sensors have been installed every half-mile covering both directions of the freeway. They are installed at driver eye level to ensure the system is reporting the current conditions as seen by the driver. In addition, the project team has installed SmartSensor HD radar spot speed sensors from Wavetronix every quarter-mile through the project area. These radars are capable of measuring traffic volume, classification, speed, lane occupancy and presence in both directions of travel. Figure 1 shows the sensors on the roadside. These two sensing technologies combine to provide a more complete picture of traffic and visibility conditions than has ever been attempted on a large scale.

The data from the sensors will be used to assess both visibility conditions and, equally importantly from the perspective of both travelers and traffic managers, speed differential at downstream locations on the freeway.

Due to the relatively rural nature of the project area, dedicated wire line communications are not available. Moreover, even if they were, the cost of trenching to connect into such systems would be prohibitive. As a result, all system communications are wireless. The communications system uses Proxim wireless devices to communicate between devices in the corridor. Backhaul communications to Caltrans' Transportation Management Center (TMC) is done using Verizon Wireless EVDO modems. Also due to the scarcity of fixed infrastructure, forty percent of the field equipment runs on solar power.

Data processing ensures that the data collected in the field is available in a useful format to travelers and to traffic managers. The system was developed with two levels of data processing.

Under normal system operations, all data are collected in the field and transmitted wirelessly to the TMC. There it is processed using the Cameleon™ ITS platform developed by ICx 360 Surveillance. If there are significant speed differentials on the freeway or if there is fog, Cameleon automatically generates messages for the data dissemination systems. If an incident has occurred, the CMS's will warn drivers of slower traffic ahead in order to prevent chain-reaction collisions.

Planned enhancements include providing the speed and visibility data from the system to the new 511 traveler information system for the southern Central Valley. The 511 system will inform travelers of problems in the project area via the telephone and the Internet before they reach it, possibly before they even leave their home or office. This will help reduce the impact of severe fog by minimizing the number of vehicles on the roadway.

As the system is further refined and enhanced, Caltrans envisions that it will have some or all of the following features:

- Full Matrix Color CMS to provide better information

- Road Weather Information Systems (RWIS) at various locations to monitor the full range of weather conditions, including rain, wind, humidity and temperature. The data from these sensors could potentially be used to predict fog.
- HAR reports, with alerts to travelers using extinguishable message signs
- Closed Circuit Television Cameras to provide more detailed information to the TMC and to the public over the Internet
- Pulsing in-pavement lighting to be used to slow traffic down under certain conditions (such as when there is an incident ahead) The lights would not be used during low visibility until an incident has occurred for fear the lights would guide drivers to move at unsafe speeds.
- Thermal Cameras
- Incident detection using advanced radar detection

Transportation Outcome(s): The system alerts motorists automatically of dangerous weather conditions and slow speeds by using CMS's and HAR. When slower speeds are detected downstream, the CMS's warn drivers of the slower traffic ahead. If an incident has occurred, the CMS's will warn drivers of slower traffic ahead in order to prevent chain-reaction collisions.

Presently, the system only employs CMS's and HAR to communicate road conditions t0 travelers. Both of these methods are very effective. The addition of the 511 system addresses the shift to mobile data devices and the increased reliance by the motorist on receiving this information while traveling. Once the fog detection data is integrated with the 511 system, it will help reduce the impact of severe fog by minimizing the number of vehicles on the roadway.

Implementation Issues: The FDWS installation involved a very short design-build cycle and innovative uses of existing technology. A number of issues were encountered in the implementation of the FDWS:

- Internal controls needed to be reconciled with the aggressive schedule and cost constraints of the FDWS.
- Existing infrastructure had to be reconfigured in order to merge the old and new components into a unified system, under the control of the Cameleon software.
- Evaluations of new technologies, such as Color CMS's, took time and resources to complete.
- User interfaces to the TMC needed to be developed around existing procedures, policies and systems.
- Caltrans policies regarding information technology security issues needed to be addressed due to the nature of the communication systems deployed by the FDWS.

Additionally, the density of detectors was limited by funding. In general, more detection capability equates with a more robust coverage of fog events. However, the nature of the funding for this project, did not allow for even small deviations from the allotted and agreed upon budget. Finally, there were concerns regarding the aesthetics of the project, due to the perceived clutter that the number of proposed field elements would present to the motorist.

Contact(s):

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- Michael Berman, ICXT, michael.berman@icxt.com

Reference(s):

- Fresno Fog Detection and Warning System <http://gs.flir.com/uploads/file/case-studies/case-study_caltrans-fog.pdf>

Keywords: Fog, Weather, ATMS, Warning System, Detection, Speed, Visibility, Wireless, Solar Power.

California DOT Icy Curve Warning System

Fredonyer Pass, located in northeastern California, is a five-mile segment of State Highway 36 in Lassen County that has a history as a high-collision location, including multiple fatal crashes involving local residents. The vast majority of these crashes (note in this document, the terms crash and collision may be used interchangeably) occurred when the pavement was icy, despite static signage that the California Department of Transportation (Caltrans) had installed to increase motorist awareness.

To address this, Caltrans deployed a system consisting of pavement sensors to detect icy conditions, in combination with dynamically activated signage to provide motorists with real-time warning when icy conditions are either imminent or present. The intention of the system was to use real-time messaging to increase motorist vigilance and reduce the number of crashes occurring during icy pavement conditions. The system consists of pavement sensors to detect icy conditions, in combination with dynamically activated signage to provide motorists with real-time warning when icy conditions are either imminent or present. It alerts motorists of icy conditions, eliciting a decrease in vehicle speeds during such conditions. Consequently, lower vehicle speeds are expected to translate to reduced crashes along the length of the curves which have presented safety challenges in the past.

System Components: Each system consists of a Road Weather Information System (RWIS) with roadway sensors and two Extinguishable Message Signs (EMS) with flashing beacons. Specialized scripts are executed in the RWIS Remote Processing Unit (RPU) that evaluate the status of the roadway sensors and determine when the ice warning should be active. A signal from the RPU then turns on the warning signs. At the summit system, a Closed Circuit Television (CCTV) camera is also present to allow the TMC in Redding to monitor conditions at the pass.

Figure CA-2. Road weather information system at Fredonyer East ICWSs.

System Operations: This system is collectively known as the Fredonyer Pass Icy Curve Warning System (ICWS). It is comprised of two similar but separate warning systems: Fredonyer Summit ICWS and Fredonyer East ICWS. The technologies employed in each system include a RWIS, which continuously monitors the road surface condition and identifies when icy or packed snow conditions are present; and two EMS, which provide dynamic warnings to motorists when icy or packed snow conditions are present.

One RWIS is placed in the heart of each curve at a location determined by to experience icing conditions most frequently. One EMS was placed on the approaches to each curve at a location to provide adequate braking distance for vehicles headed into an icy curve.

A schematic showing the location of the Intelligent Transportation Systems (ITS) elements of the system is presented in Figure CA-3.

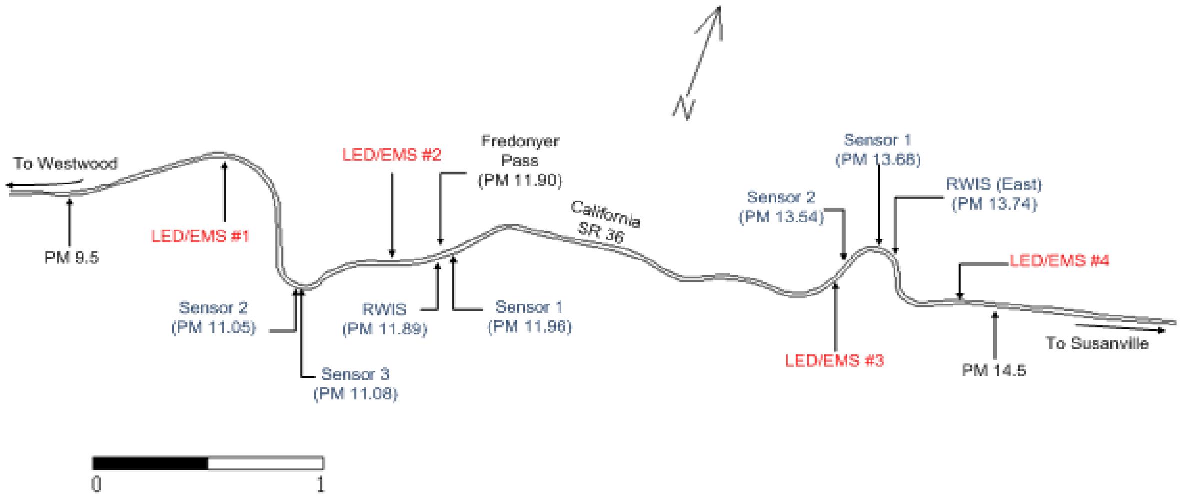

Figure CA-3. Schematic of Fredonyer Pass and Icy Curve Warning System.

The original, vendor-supplied system components were installed during the summer of 2002, including RWIS pavement sensors, RWIS towers, solar panels, and EMS. Over time however, it became evident that this system would not reliably operate in the manner envisioned by Caltrans. Instead, the system was rebuilt by Caltrans District 2 ITS Engineering and highway maintenance personnel. Ice detection optimization continued for about two seasons after the hardware was corrected.

Transportation Outcome(s): In order to determine the safety effects of the ICWS, an observational before-after study using the Empirical Bayes technique was employed. This evaluation determined the effect of ICWS on crash frequencies. The results found that the deployment of the ICWS reduced the number of annual crashes by 18%. As no other changes occurred along the study segment (additional safety improvements, geometric changes, etc.), it is reasonable to attribute this observed safety improvement to the ICWS. Additionally, a crash rate method was used to investigate the effect of the ICWS on crash severities, with a focus on ice-related accidents. The results indicated that the ICWS has reduced crash severities. As an outcome of reduced crash severities, the system was estimated to provide safety benefits of $1.7 million dollars per winter season during the after deployment study period (2008-2009, on account of time lag in crash data availability). Given that 1.5 years of after-period data was available for analysis, it would be advisable to revisit the safety performance of the Fredonyer ICWS at some point in the future when more years of crash data are available. Overall however, the initial safety evaluation results indicate that the system is having a positive impact on reducing crashes.

From the perspective of winter maintenance personnel, the ICWS is an improvement over typical static metal signage. Observations made over time have indicated that as the winter progresses, the system works better. The use of additional pavement sensors for detection of conditions in multiple lanes could improve system accuracy and reliability. The data produced by the ICWS is not presently employed by maintenance forces for any activity, although the CCTV camera associated with the system's RWIS at the summit is used frequently to obtain visual information on present conditions.
The ICWS's in District 2 are the only focused pavement section ice detection and warning systems that have been successfully deployed and function properly. While the results are preliminary while data collection is ongoing, there may be a real and significant safety improvement and improvement in driver behavior due to the systems' presence. Traditionally,

these types of problem areas required an expensive roadway realignment to solve reoccurring icing. Deployment of ICWS systems may allow for an interim, lower cost option that provides a safety benefit until funds for a full realignment can be secured.

Implementation Issues: The ICWS was not considered fully operational and reliable until the winter season of 2008-2009. Following, an evaluation of the performance of the ICWS focusing on the metrics of speed reduction under various conditions and safety performance through crash reduction was conducted. The results of the statistical analysis of speed data suggest that the system is working as intended and that vehicle speeds are significantly lower. As one would expect, mean speeds were lower when the system was turned on versus off as well as during the day and at night. When general wet weather (snow, rain, etc.) conditions were evaluated, it was found that mean speeds were reduced when the system was on versus off during both the day and at night. The real effectiveness of the Fredonyer ICWS on vehicle speeds is its impact during clear, cold and not dry conditions, when snow melting or general water/ice pooling from the wet and cold environment of the curve locations may produce runoff across the roadway in the target curve and result in ice formation. Mean speed differences exceeding 3 mph were observed during such conditions during both the day and at night at a majority of sites. However, only a limited number of mean speed differences were found to be greater than 5 mph. As the speed readings employed in this evaluation were collected at sign locations in advance of the curves of interest/concern targeted by the ICWS, it is possible that the observed changes in mean speeds reported here are translating into even more significant reductions by motorists as they enter and traverse each curve. When examining different levels of manned chain control versus the system state and time of day, it appears that the greatest impact of the ICWS is when R-1 control is in effect. (R-1 control is a requirement for chains on tires of commercial vehicles, and snow tread tires or chains on all other vehicles.)

Feedback by Intelligent Transportation Systems (ITS) engineering indicated that following the rebuilding of the ICWS, it is generally functioning as expected. However, observations over several years of operation have indicated that the system has difficulty identifying road conditions during the early winter. The use of additional sensors in such cases would address this issue. Also, employing data from supplemental sensors (such as air temperature, precipitation, et cetera.) could possibly allow the system to compensate for times that roadway surface temperature and condition data is not sufficient in identifying potential icing conditions. When considering similar systems for deployment elsewhere, it is especially important to select roadway sensors that can be tested and calibrated easily, and to employ data collection equipment in the system that uses open and easily programmed software.

Finally, feedback provided by the California Highway Patrol (CHP) indicated that drivers appear to be slowing down when the ICWS is on (particularly in vicinity of the targeted curves). This is only perception though, and there has been no analysis performed by CHP (on ticket records, for example) to verify whether it is in fact the case. It was also believed that crashes over the pass have dropped in recent years although, again, no analysis of data has been performed to confirm this view. The thoughts of CHP on this drop were that it could be related to the ICWS, as well as manned chain control policies employed by Caltrans. In general, the system appears to be accurate in indicating ice conditions.

Contact(s):

- For system information:

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- For evaluation information:

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Keywords: Icy, Ice, Ice Detection, Automated Warning, Safety, Performance, Weather, Visibility, Wireless, Solar Power

Colorado DOT One Pass Clearing Operations

Many agencies continue to be challenged with removing snow on an increasing number of lanes and shoulders with the same or fewer trucks and operators, while still needing to meet the public's expectations. There is a necessity to identify how to plow wider and faster to maintain or increase services without adding personnel. The Colorado Department of Transportation's (CDOT) original goal was to double operator production to meet the expected levels of service. There are two approaches tried and proven:

1. Using wider front plows to clear a 12 foot lane in one pass (see Figure CO-1) has been proven to reduce the number of passes (rounds) needed, has saved fuel and has reduced labor costs. The expected savings for average fuel costs and average labor costs are between 20% and 50%. The benefit to cost ratio exceeds one the first year.

2. Trailer plows, also known as Tow Plows (TP) (see Figure CO-2); have allowed one snow plow truck and one operator to clear widths over 24 feet at high speeds, providing a level of performance never before seen in the industry. Previous trucks with wing plows generally cleared a path of 16 feet or less at speeds less than 30 miles per hour. TPs have cleared up widths up to 25 feet at speeds above 50 mph in open, safe conditions. The benefit to cost ratio exceeds one when it replaces a second truck, and it exceeds one within one year to five years of operation.

Figure CO-1.
Truck with 14 ft. wide front plow.

System Components: Most transportation agencies use 10-foot, 11-foot, or 12-foot front plows. Using a 14-foot front plow allows one operator to clear one lane in one pass, from centerline stripe across either edge line stripe. The extra cost of 14-foot plows is miniscule compared to the current cost of front plows.

TPs allow one operator to clear widths up to 25 feet, with the ability to vary the clearing path from 11 feet to 25 feet with a simple control in the cab. The TP hooks and tows behind a snow plow truck. In operation, it can be steered into the adjacent lane, clearing and treating an additional lane in the same pass. The TP can be steered around parked cars as needed. The cost of a TP is less than the cost of a conventional snow plow truck.

Figure CO-2. Tow plow being loaded with salt.

System Operations: A front 14-foot plow, when properly designed, can vary its clearing path from 11.5 feet at 35 degrees to 12.5 feet at 25 degrees, by using the original control sticks in the cab for other front plows. The former plow position can provide fuel savings due to its acute angle and the latter can clear a 12-foot lane in one pass. It hooks to the trucks just like other front plows.

A TP hooks to a snow plow truck like any trailer with air brakes and it needs controls to deploy. Agencies have used the existing hydraulic controls on wing plow trucks to deploy TPs. One can divert the hydraulics used for existing wing plows to provide steering and moldboard lift. Another option is to add two hydraulic valves and duplicate the front plow control stick. With this option, one stick deploys and retrieves the TP.

TPs with spreaders require additional hydraulic circuits for spreader and fan controls. Some TPs are self-sufficient by having on-board diesel power and hydraulics. Such TP units can be used as brine trailers for anti-icing practices while in tow before a snow storm, or during the storm while deployed.

Transportation Outcome(s): Wider front plows provide tremendous advantages on interstates and expressways because they clear an entire 12-foot lane, thereby eliminating the need for a second round and reducing the exposure time and frequency of exposure between snow plow trucks and traffic.

The practice can also clear both the center line stripe and either the left or right edge line stripes when clearing the 12-foot lane in one pass resulting in exposed stripe markings earlier in the snow storm.

A third advantage is that the practice discharges the windrow beyond the edge lines, positioning it such that it is more difficult for traffic to suck the windrow back onto the pavement between cycles of plowing. In general, two lane collector roads (with and without shoulders) and rural interstates can benefit by clearing the entire lane in one pass.

There has been some indication that eliminating the second plowing round on collector roads (which have adjacent ditches and no shoulders) may eliminate snow plow truck accidents by allowing the operator to discontinue crowding the edge of pavement on the second round. Further, when the operator does not make the second round, he cannot plow off the first pass chemical treatment, thereby eliminating the need to apply a second application of chemicals.

TP trucks can do the work of two snow plow trucks. One such manifestation of this capability is clearing the truck climbing lanes on the first round, and thus immediately returning the climbing lane to service instead of waiting until the second round. Similarly, TPs can benefit routes with reverse passing lanes where snow plow trucks need to clear two lanes for a few miles and then only one lane (and shoulder) for several miles, repeating this alternating passing opportunity for many miles. Therefore, passing opportunities are provided immediately after the first round.

Implementation Issues:

- Many state transportation agencies have assumed that 14-foot front plows cannot operate on highways. However, the Missouri Department of Transportation now has over 500 plows operating on interstates, expressways, urban multilane signalized areas and collector roads with 10-foot, 11-foot, and 12-foot lanes with and without shoulders.
- Accessibility to maintenance shops for parking and blade-changing may be an issue; however, the 14-foot plows are designed to pivot farther and the moldboards are clipped to allow entry into buildings.

- These plows must be used on an appropriately sized truck. The 14-foot plows were first implemented on ten-wheelers but are now used and proven on six-wheelers with gross vehicle weight ratings of 26,000 lbs. or more. These plows are not to be used on lighter trucks. Most trucks have 12,000 lb. front axles or heavier.
- There may be some concern with the operating width of the 14-foot plows. Plow designs cause the clearing path to always favor the discharge side. Thus, the leading edge is no closer to center line than conventional 11-foot and 12-foot plows. Additionally, the truck mirrors are at least nine feet wide on most trucks. Therefore the front plow is only just outside of the mirrors. Finally, an important benefit of this plow is that it allows the operator to reach the edge of pavement without crowding the steer tire to the edge of pavement.

There are several implementation concerns with the TP, such as the following:

- "Too large to operate on our highways!" Very few could believe that one could plow two lanes wide with one truck and do it safely. TPs have proven to be safer for gang plowing by eliminating many of the gaps between existing trucks. Brine tanks or spreaders have provided conspicuity for rear recognition to avoid rear end accidents.
- "Our snow plow trucks do not have enough horsepower to pull." TPs operate at extreme angles from 60 to 90 degrees compared to front plows which operate at 30 degrees from the rear. This acute angle provides better casting to move snow with less horsepower.
- "It costs too much." A TP costs ten times as much as a front plow, but it replaces a second truck and operator.
- "Our wing plows are being hit from the rear so the TP, being larger, would create more accidents". All TPs are required to have brine or material spreaders lending conspicuity to the rear. Practice has proven that TPs do not get hit like wing plows.
- "The TP will not handle our deep snow storms." Videos of operations in Maine, Canada, and in areas of Ohio with lake effect show that Tow Plows can handle deep snow quite well.
- "We cannot use a TP truck blocking traffic on a two-lane rural interstate highway." This had been a major concern, but with field experience it is being overcome. In some cases the use of TPs is preferred and endorsed by the state highway patrol. Seek more information on this issue from the contacts listed below; specifically, Robert G. Lannert can provide current information and states' practices.

For cautionary purposes, it should be noted that snow plow trucks should always operate at safe speeds for the conditions. Operators should always follow agency protocol and procedures. Operating speeds must consider the equipment design, potential obstacles, the road condition (rutting, potholes, friction, and operating environment), and the operator's training and abilities. There are major differences in front plow, wing plow, and underbody plow designs where some may not safely operate at speeds above 20 mph to 40 mph, much less than rural interstate speeds. However, plowing faster can reduce or eliminate rear end accidents with snow plow trucks.

Contacts:

- Robert (Bob) G. Lannert, Retired MoDOT Engineer, Maintenance Operations, (Mr. Lannert's current telephone number can be obtained via a request through email to MoSnowKing@aol.com).
- Tim Chojnacki, MoDOT Maintenance Operations, E-mail Mr. Chojnacki at Tim.Chojnacki@modot.mo.gov for current telephone number and information about MoDOT's experience with more than five 14-foot plows and more than 70 TPs.

- Phil Anderle. Contact Mr. Anderle at 970-350-2100 or Phillip.Anderle@DOT.State.Co.Us for questions about Speed Management on Colorado I-70 and other routes using Patrol cars and snow plow trucks to maintain safe travel speeds and provide continuous flow of traffic during inclement weather conditions.

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Keywords: One pass clearing, 14' snow plow, trailer plow, tow plow, high speed plowing.

Colorado DOT Variable Speed Management System

Colorado State Highway 82, in Snowmass Canyon (between Aspen, CO and Glenwood Springs, CO) is composed of an elevated southbound roadway that shades the northbound roadway during certain times of the day causing rapidly changing freezing conditions. The Colorado Department of Transportation (CDOT) installed the Variable Speed Management System which consists of a complete Road Weather Information System (RWIS), using newly developed non-intrusive pavement weather sensor technology. The pavement sensors monitor traction/friction conditions in the area that is shaded, and allow for alerts when conditions warrant. The system is capable of monitoring wet conditions, wet conditions with traction loss as freezing begins, and snow and ice conditions. The system wirelessly communicates to a single variable message sign (VMS) and a single variable speed sign (VSS) that are located nearly a mile in advance of this northbound section of highway in Snowmass Canyon (see Figures CO-3 and CO-4).

Figure CO-3. RWIS Snowmass Canyon.

Figure CO-4. Alert of wet roads.

System Components: The system consists of the following major components:

- Variable Message Sign
- Road Weather Information System (RWIS), which consists of the following:
  - Remote Processor Unit
  - Non-Intrusive Surface State Sensor
  - Non-Intrusive Surface Temperature Sensor
  - Air Temperature/Relative Humidity Sensor
  - Precipitation Identifier and Visibility Sensor
  - Ultrasonic Wind Sensor
  - Pan-Tilt-Zoom Color Camera
  - Relay Device Control
  - Wireless Device Control

System Operations: The system provides continuous monitoring of atmospheric and pavement weather conditions to determine changing driving conditions that will impact the motorist and alert transportation managers of these changing conditions. The Non-Invasive pavement weather sensors are capable of monitoring changing traction values that will impact driving conditions for the motorist. They are also capable of alerting the motorist of these conditions by displaying messages on the variable message sign and potentially providing advisory speed limits as a result of these changing pavement conditions.

The system monitors current atmospheric conditions by monitoring when precipitation is occurring in the form of rain, freezing rain, or snow, with the ability to display rates and accumulations. The system is able to provide alerts to Colorado Department of Transportation (CDOT) operations of these changing atmospheric and pavement weather conditions allowing for remote access to conditions by computer and cell phone. The camera allows for live images of changing weather conditions at the site.

The system monitors traction level thresholds. When slippery thresholds for wet and icy thresholds are reached, activation of different messages such as “Wet Roads Ahead” or “Icy Roads Ahead” are produced by the RWIS processor. The “wireless device control”, utilizing spread spectrum radios, activates these different messages in the VMS that is located nearly a mile in advance of this stretch of highway. The “wireless device control” also is capable of providing different controls for different suggested speeds with the “variable speed sign”.

Transportation Outcome(s): The unique road topography of Colorado State Highway 82 caused shading and precipitation build-up on certain portions of the road at various times of the day, resulting in a large number of winter weather related accidents during the several years prior to the installation of this Intelligent Transportation System. The first winter of operation resulted in no winter weather related accidents in this section of highway in Snowmass Canyon.

Implementation Issues: Buried telephone was not readily available at the RWIS and VMS sites so a wireless cell phone modem was installed at the RWIS site to communicate to the RWIS site. Communication was also established from the RWIS site to the VMS site using a spread spectrum radio system as described previously. Even if there is a cell phone outage the RWIS can communicate to the VMS site.

The Variable Speed Limit Sign which was installed and operated with no issues, but was later removed at the request of CDOT Staff Traffic.

Contact(s):

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Reference(s):

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Keywords: Intelligent Transportation System, atmospheric weather sensors, non-invasive pavement weather sensors, hazardous atmospheric weather, road weather traction conditions, and alert motorists alerts, variable message signs, variable speed signs

Florida DOT Bridge Wind Speed Alerting System

The Florida Department of Transportation (FDOT) has deployed a high-wind alert system for road bridges. The system assists the transportation and public-safety communities by providing real-time wind speed status information during severe weather events from each monitored bridge structure. This information is used to assist transportation managers with bridge closure decisions.

Historically in Florida when a severe weather event occurs, such as a tropical storm, hurricane, or nor'easter, local law enforcement personnel must deploy to each bridge in advance of the weather event. The officer takes periodic wind speed measurements and reports the information to their local law enforcement agency which may eventually make the decision to close a bridge. This protocol puts law enforcement personnel in harm's way unnecessarily and deploys them inefficiently precisely during a time when they may be needed elsewhere. Further, requiring them to make wind speed measurements with hand-held anemometers is not an accurate means of collecting meteorological data. There is also minimal dissemination of the pertinent wind speed data to local and regional public safety and transportation stakeholders with this protocol.

With the new FDOT wind alert system, these shortcomings will be addressed. The data is reliably collected from the system, and it is automatically and instantly disseminated to FDOT Regional Traffic Management Centers (RTMC) and to local public safety officials. All parties will have more accurate data from which to make informed decisions about critical issues like bridge closures and evacuation routes.

The system has been deployed on over twenty bridges in northeast Florida as part of a pilot project. All critical waterway bridges and interchange flyovers in this area of the state were instrumented. This included all barrier island bridges, most river bridges and the three major highway interchanges in the Jacksonville, FL area.

The reduced expenses associated with this project is due to the use of low cost wind-only detectors and solar-powered satellite transmitters that utilize a free telemetry service offered by the National Oceanographic and Atmospheric Administration (NOAA) called the Data Collection System (DCS). There is therefore no monthly reoccurring operational cost for the system (other than maintenance). The installation cost to instrument a bridge is approximately $10,000 (material and labor). FDOT is currently procuring satellite communications ground station equipment to enhance the dissemination of data to RTMCs state-wide.

Figure FL-1. FDOT bridge wind speed monitor installation.

System Components: Each bridge is outfitted with a Data Collection Platform (DCP) that includes an ultrasonic wind sensor installed at approximately ten feet above the bridge road deck, as shown in Figure FDOT-1. The wind sensor connects to a data logger that performs analytics to discern wind gusts and continuous high winds. Multiple alarm thresholds are used to detect high wind conditions, triggering the data logger to transmit an alert message via a NOAA Geostationary Operational Environmental Satellite (GOES). The satellite transmitters are solar powered. The GOES transmits alerts to FDOT, where they can be disseminated via the FDOT statewide area network or via the Internet.

System Operations: Sampling of wind conditions is designed to maintain a low-power draw for the installation. Wind measurements are performed during one minute sample periods that are spaced ten minutes apart. Wind anomalies associated with passing vehicles are filtered out during this process, ensuring that only continuous winds and gusts are reported.

If the wind conditions trigger any of the multiple alarm thresholds, one or more alert messages are relayed via GOES to FDOT. Currently, FDOT is building two satellite communications ground stations to receive bridge wind alerts from GOES. Once received, those alerts are disseminated to the state-wide RTMCs. The main ground station is strategically located away from the coastline and next to a FDOT communications network hub. FDOT operates a redundant statewide area network over microwave and fiber links that provides a highly reliable connection to the RTMCs (these connections are 99.999% reliable, experiencing just 5 minutes of down time per year). This feature will help ensure that data is securely and reliably disseminated to the RTMCs even during severe weather events that may compromise commercial telecommunications infrastructures.

In the RTMCs computers will monitor the wind speed alerts and display them graphically on a map of the area. Alerts are received at the RTMC once wind speeds at any bridge reach thirty miles per hour (mph). Alerts continue to be received for each additional 5 mph incremental increase. The RTMC personnel can inform local public safety officials of each new alert condition on a bridge, giving law enforcement officers enough time to deploy and secure a bridge for closure. The system will also inform RTMC personnel when wind conditions are receding.

An additional software tool is being developed to provide authorized local public safety and emergency management personnel direct access to the wind speed data. FDOT is developing an Internet web application that will permit local officials to monitor the FDOT wind alert data securely over the Internet via dissemination from the NOAA ground station in Virginia. This secondary means of viewing the wind alerts will give hundreds of authorized public safety officials the ability to monitor local bridge wind speed conditions without compromising FDOT internal network performance or security.

Transportation Outcome(s): This new FDOT bridge wind speed alerting system will provide a more efficient, safe, and accurate method for collecting and disseminating information about potentially dangerous wind conditions on bridges. In addition, this new system will be able to share severe weather data with the FHWA and its *Clarus* initiative, as well as other agencies such as the National Weather Service.

One of the most significant benefits of this project is the low-cost way in which it was implemented. The use of the NOAA GOES system to collect wind speed alerts from the bridges will create a substantial savings on operational costs. For example, had FDOT used cellular telephone modems (a common approach) to communicate with the bridge DCPs, an eventual statewide deployment could cost the state $750,000 over five years, just for the cell phone bill. The use of solar panels saves even more money since running power lines to remote bridge locations is very expensive.

Implementation Issues: The installation of the bridge wind speed monitors required FDOT and its contractors to develop a mounting method that was performed quickly to minimize lane closure time, but also robust enough to withstand bridge vibrations and severe wind conditions. The location on each bridge was usually chosen to be the highest point, but also a point with a clear view of the southern sky so that the satellite transmitter could communicate with GOES. To avoid return visits to bridges to make installation changes, each bridge DCP was configured and initially tested on a rooftop Florida DOT test stand before being deployed.

Contact(s):

- Randy Pierce, Florida DOT Telecommunications Administrator, 850-410-5608, randy.pierc@dot.state.fl.us
- Peter Vega, Florida DOT District 2 ITS Engineer, 904-360-5463, peter.vega@dot.state.fl.us

Reference(s):

- Florida DOT, *Sunguide Disseminator Newsletter*, October 2011. "A New Public Safety Focus for FDOT and ITS," <http://www.dot.state.fl.us/trafficoperations/Newsletters/2011/2011-010-Oct.pdf#page=5>
- NOAA Data Collection System Website <http://www.noaasis.noaa.gov/DCS/>

Keywords: wind, bridge, high wind warning system, public safety, emergency management, traffic management centers, advisory strategy, severe weather, hurricane, tropical storm, evacuation, high-profile vehicles, safety, satellite, NOAA, data collection system, data collection platform, sensor, solar-power.

Idaho TD Winter Maintenance Performance System

The Idaho Transportation Department (ITD) is in the final stages of developing its Winter Maintenance Performance Measures System which will include 87 Road Weather Information System (RWIS) sites. At the time of publication, sixty sites are operational. Statewide implementation of the system began in 2011. Currently, ITD is identifying the performance levels of its winter maintenance operations in all districts. Depending on the results of this effort, some existing maintenance practices in various locations may be altered to increase operational efficiencies. ITD anticipates there will be several seasons of continual improvements in the RWIS network while allowing time for appropriate operational adjustments to be made.

Figure ID-1. RWIS installation at Goose Creek Summit on State Highway 55 in central Idaho.

System Components: Each RWIS site (see Figure ID-1 for an illustration), in addition to the atmospheric sensors, typically has two road surface sensors: one to measure the road's grip coefficient (DSC111); and one to measure road surface temperatures (DST111).

Additionally, ITD is developing a system to automatically track maintenance data. Similar to many states, ITD is moving toward Automatic Vehicle Location (AVL) and Mobile Data Collection (MDC). Information on salt usage, anti-skid, liquid quantity usage, application rates and plow down/up time is currently manually recorded and entered into a database.

ITD plans on automatically collecting this information from its winter maintenance fleet, and integrating it into the state's Maintenance Management System (MMS) database – thereby eliminating the human generated reports that were time consuming and error-prone.

Having such an automated system will also allow ITD to integrate with the automated RWIS performance measure system for expedited data fusion, allowing rapid review, critique and operational adjustments to minimize deviation from the new Best Management Practices (BMP).

System Operations: In responding to winter storms, the treatment objective is to minimize the "ice-up" time. ITD has developed a performance measure Index. Specifically, the Performance Index is a measure of ice duration per unit of storm severity. Storm severity is modeled using an empirical formula that utilizes wind speed, surface precipitation accumulation, and surface temperature. Ice duration is defined as the amount of time grip falls below 0.6. Data collected from the RWIS stations is used to determine various parameters in the Performance Index formula. This metric allows for accurate evaluation of different treatment strategies and maintenance operations.

Transportation Outcome(s): The primary benefit will be improved safety and mobility of the traveling public. Maintenance crews will now have the ability to evaluate treatment selections along with timing of applications and rates. This will lead to continual reevaluation of current

BMPs to continue the trend of reducing ice-up time. The new BMPs are anticipated to reduce time and materials for storm event clean up and better utilize resources. Anticipated cost savings from new BMPs will allow ITD to expand the RWIS network allowing other areas to reap the rewards of the RWIS data and expand the system to additional locations.

Implementation Issues: Receptiveness to the system across ITD was rather low upon the first year of statewide implementation. As the winter season progressed and the RWIS locations became more reliable and acceptable, the performance measures gained momentum. Funding was an issue initially, but with the acceptance of the system came a reevaluation of intelligent transportation system (ITS) projects; funding was redirected into the RWIS Performance Measurement and Reporting (PMR) upgrades. All 87 RWIS stations are anticipated to be PMR ready by fall of 2012. New sites are being discussed and programmed by the districts to continue the expansion process. The districts have submitted request for a complete statewide build out of a total of 140 PMR sites.

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Keywords: performance measure, ice-up time, grip coefficient, surface temperature, and best maintenance practices.

Iowa DOT Salt Use Dashboard

Spreading salt on road surfaces is one of the primary means for removing and preventing accumulation of snow and ice. The Iowa Department of Transportation (Iowa DOT) has a new management dashboard featuring actual salt usage during maintenance operations compared to estimated usage amounts, based on road weather conditions. Managers monitor this Dashboard to make sure current usage is reasonable given the weather and is within Iowa DOT's standard application rate guidelines. Development of this Dashboard is very recent, with implementation occurring in August 2011 before the start of the winter season. Already, the tool is encouraging and allowing maintenance staff to keep a tighter control on salt usage.

System Components: As seen in Figure IA-1, the salt use dashboard consists of the following elements:

- State, district, and garage-level displays
- Color-coded dials indicating actual salt usage versus the targeted usage
- Interactive graphs and charts to view area and time period of choice
- Salt purchasing status
- Comparisons to estimated 'target' use, based on storm weather information
- Comparisons to budget availability
- Daily, Pay Period, or Year-to-Date summaries

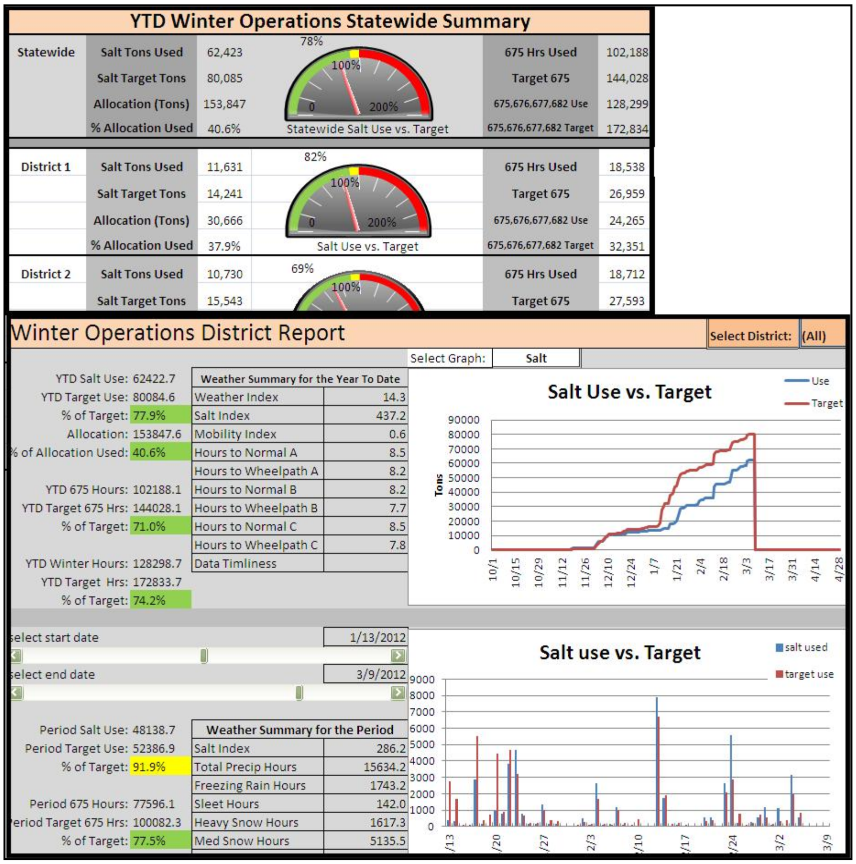

Figure IA-1. Example screenshots from the Iowa DOT Salt Use Dashboard.

System Operations: There are several inputs to the Dashboard to generate the usage visualizations and outputs which aid managers in their decision making. Road temperature information from Road Weather Information Systems (RWIS) is merged with winter storm information from standard crew reports. This weather information helps to estimate salt use rates. These rates are based on Iowa DOT salting guidelines, as derived from the “Guide for Snow and Ice Control” published by the American Association of State Highway and Transportation Officials. Garage responsibility-miles and service requirements information modify the basic rate estimates (in total salt per lane-mile) into a garage-specific daily total tonnage.

The Dashboard accesses the actual usage information and the weather-based estimates from a database and displays it in the dashboard application. Dashboard information is rerun every week and distributed to management and garage supervisors via email. Currently, the Dashboard is built in Microsoft Excel. There are plans to convert it to commercial dashboard software in summer 2012 for release prior to the winter season.

Transportation Outcome(s): The Salt Use Dashboard helps Iowa DOT ensure that salt usage and labor usage compares favorably with department guidelines. This helps provide a uniform and predictable level of service, and keeps costs within budget. It can also be used to identify practices that seem to provide better service with less salt.

Implementation Issues: Sometimes when maintenance actions adhere to the recommended salt usage rates the desired level of maintenance and service is not obtained. Iowa DOT is still investigating these cases to determine whether the guidelines are inadequate or if maintenance practices need to be altered. It is also still unclear how the usage rates should be modified for different levels of service or traffic volumes.

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- Annette Dunn, Iowa DOT Winter Operations Administrator, 515-239-1355, annette.dunn@dot.iowa.gov

Reference(s):

- Transportation Research Board, 2004. *NCHRP Report 526, Snow and Ice Control: Guideline for Materials and Methods* <http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_rpt_526.pdf>
- AASHTO, 1999, *Guide for Snow and Ice Control* <https://bookstore.transportation.org/Item_details.aspx?id=1019>

Keywords: asset management, salt use, dashboard, maintenance

Iowa DOT Weatherview Road Weather Traveler Information System

The Iowa Department of Transportation's (Iowa DOT) "Weatherview" website is an example of real-time road weather information provided for the traveling public. "Weatherview" was made available online in 1999. The current site was released in 2009. Subsequently, it has been updated to incorporate road cameras, traffic flow information, and maintenance tools like email and mobile-text alerts triggered by certain weather events. Additionally, plow truck locations obtained via Global Positioning Satellites (GPS) are reported to personnel with Iowa DOT viewing permissions.

System Components: The "Weatherview" system consists of the following elements:

- A main map to display and overlay information from Road Weather Information System (RWIS) stations and information from Automated Weather Observation Systems (AWOS), as shown in Figure IA-2
- Site-specific forecasts to aid in road maintenance, along with historical weather graphs and charts
- Camera image gallery
- Rural traffic speed information
- Features that allow Iowa DOT-authorized personnel access to
    - o Email alert subscriptions based on site observations,
    - o GPS and Automated Vehicle Location (AVL) data showing current truck locations and plow/spreader information,
    - o Work status of winter maintenance crews around the state.

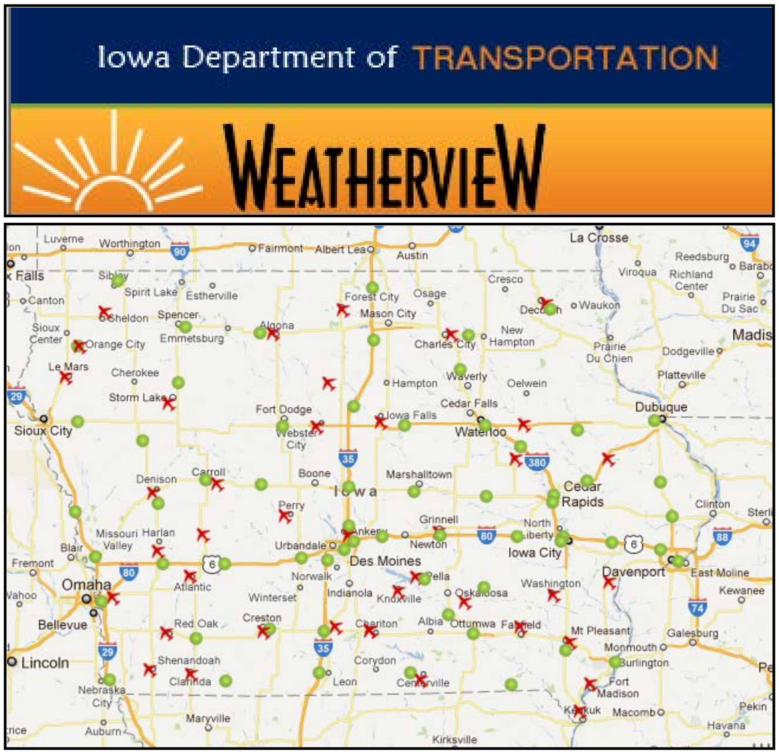

Figure IA-2. "Weatherview" website showing RWIS and AWOS site locations.

System Operations: The “Weatherview” site is hosted by Iowa DOT and retrieves current AWOS and RWIS information from the department’s databases. Google Maps software is used to manage map display functionality. The site retrieves Iowa DOT GPS and crew status map layers from Iowa DOT’s Geographic Information System (GIS) map services system.

Transportation Outcome(s): The “Weatherview” system enables easy access to real-time, useful weather information to travelers, Iowa DOT maintenance crews, local agency maintenance crews, and the general public. This information is used to make treatment decisions, is shared with airport commissions to help organize flight plans, helps to monitor road conditions and traffic flow in inclement weather, and aids in planning daily travel or activities.

Implementation Issues: The new “Weatherview” website contains more high-bandwidth products than the original, especially Google mapping and camera images. The site has required more server capacity in order to provide quick and reliable information to the thousands of users that access it during a storm. The additional advanced functionality also makes it more complicated than the original site, requiring more information technology support staff to maintain it.

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Reference(s):
- Weather View website <http://weatherview.iowadot.gov>

Keywords: Road Weather Information, travelers, website, real-time, mapping

Kansas City Scout Advanced Traffic Management System

Kansas City Scout (KC Scout) is a comprehensive traffic congestion management and traveler information system conceived, designed, and operated jointly by two Departments of Transportation. In September of 2001, the Missouri Department of Transportation (MoDOT) and the Kansas Department of Transportation (KDOT) jointly announced their bi-state initiative to address traffic impacts on over 100 miles of contiguous freeways intersecting both sides of the state line throughout the greater metropolitan Kansas City area. Kansas City Scout encompasses the jurisdictional boundaries of Cass, Clay and Jackson counties in Missouri and Johnson County and Wyandotte County in Kansas.

Providing the core platform for Scout's Transportation Management Center (TMC) operation is its state-of-the-art TransSuite™ Advanced Traffic Management System (ATMS). Within this framework, Closed Circuit Televisions (CCTVs), Dynamic Message Signs (DMS) and Vehicle Detection Stations (VDS) are controlled and monitored. Commencing operations in summer 2011, this system integrates weather information with the pre-existing traffic management capabilities of KC Scout. The integrated system was tested during winter 2011 and into the summer months. Evaluation will continue through April 2013 in order to capture data for two complete seasons.

Prior to September 2009, Scout used a UNIX-based system that provided little support for enhancement development, report generation or operator efficiency. Many manual workarounds were developed by Scout staffs that were time consuming to create and maintain but provided the level of utility desired to create and monitor incidents, track activity, and provide management reporting capabilities. Inbound weather information consisted of daily MoDOT radio broadcasts of WeatherOrNot™ furnished forecasts or Internet-based weather media channels monitored on individual desktops. Scout operators became adept at identifying changing weather conditions while constantly monitoring CCTV cameras spanning over 100 miles of interstate in the metro KC area.

With the recent upgrade to ATMS, Scout is able to integrate weather information into the user interface as another "layer" utilizing the data available from external weather information sources, such as National Oceanic and Atmospheric Administration (NOAA), National Weather Service's (NWS) National Digital Forecast Database (NDFD), and Meridian-511 providers.

System Components: The KC Scout TMC was completed and opened in late 2003. It is an integrated system of 138 CCTVs, 38 DMS, 277 VDS, a highway advisory radio (HAR) system and a dynamic web site offering users the capability of designing their own customized alert messaging profiles. The user-interface utilizes a series of "layers" that visually represent infrastructure (CCTVs, DMS, VDS), traffic incidents, scheduled events (roadwork) and special events (heavy traffic stadium/concert events). The new ATMS software binds the various sensing components, communications infrastructure, weather information, and user interfaces.

System Operations: The Windows/SQL-based TransCore™ product has streamlined all the processes associated with creating and monitoring traffic incidents, activating and updating DMS message boards and linking all pertinent incident information – including weather – into easily accessible databases and reporting tools.

As an example, when a weather condition exists that meets pre-selected alert threshold criteria, a "layer" will "activate" on the operator's ATMS desktop map application, signaling creation of a weather event type "incident" with applicable DMS messaging and outputs to Scout's website and subscriber-configured WebAlert applications.

Furthermore, during winter storm events, MoDOT's traffic department staffs a separate workstation within the TMC, solely for the purpose of monitoring road conditions and reporting on the snowplow activity within its local coverage area. This is of great assistance to KC Scout operations because the information can be used to post DMS messages in advance of the plows, helping to keep those lanes clear of through traffic that would otherwise impede plowing activity.

Transportation Outcome(s): The quickness of being able to notify motorists of a rapidly developing severe weather condition will aid in their decision making and hopefully reduce severe weather related crashes on the interstate. It is expected that this system, with its enhanced and integrated weather information, will result in timelier messaging for the traveling public, along with more proactive internal sharing of weather information between operations and maintenance, and will result in improved highway performance and traveler safety. Figure KC-1 further details benefits from the system.

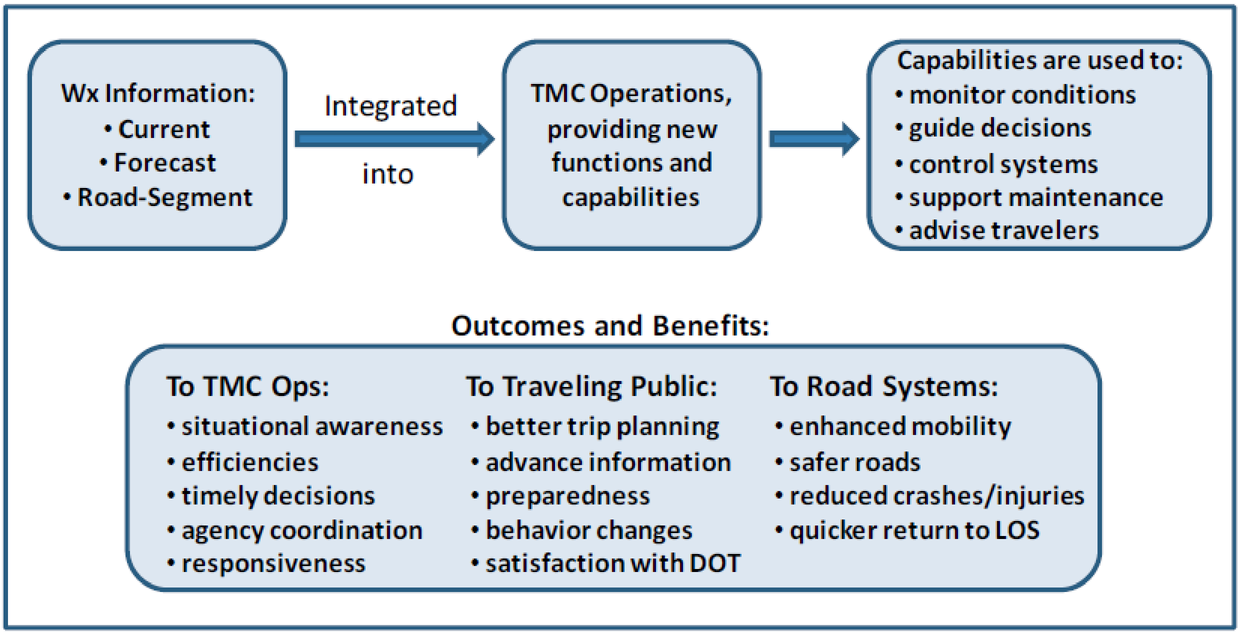

Figure KC-1. Kansas City Scout's ATMS integrated with weather information.

Implementation Issues: There are several ongoing concerns for operation and implementation of the system. It is critically important that the integrated ATMS system is fully operational, including functional DMS and CCTVs, for example. Also, operators need to be properly trained in the use of any new components associated with the acquisition, integration, processing and dissemination of weather information.

In regards to the recent software transition, the Windows/SQL-based TransCore™ product deployment was nearly seamless. Training on the use of these new elements required TMC staff development along with support system documentation.

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- Nancy Powell, TMC Supervisor, KC Scout, nancy.powell@modot.mo.gov

Reference(s):

- RITA Intelligent Transportation Systems Joint Program Office, February 2011. *Weather Information Integration in Transportation Management Center Operations*, Final Report, FHWA-JPO-11-058, February 2011 <http://ntl.bts.gov/lib/38000/38600/38677/TMC%20Final%20Report%20Website%206.13.11/tmc_integration_report_final.pdf>

Keywords: traffic management, software, transportation management center, road weather information system, customized alerts, Kansas City

Kansas DOT Road Weather Information for Travelers System

The Kansas Department of Transportation (KDOT) Road Weather Information for Travelers System shares road condition information with the traveling public in Kansas. This information is used for making travel decisions before travel commences and during travel. Initially, the information was provided by a road condition website, known as KanRoad, and a toll-free hotline that provided periodic information and required manual recordings about general road/weather condition information.

In 2000, the United States Department of Transportation was granted the 511 number for disseminating traveler information. Additionally, the Federal Highway Administration made funding available that helped KDOT evaluate its traveler information system for content, method/frequency of delivery, cost, accuracy and reliability. KDOT decided to deploy a Statewide 511 System that would ultimately provide significant improvements over the existing KDOT hotline used during the winter months.

The Kansas 511 System was deployed in January 2004 and is a fully automated system that provides near real-time route and segment-specific information for state highways and Interstate highways. Kansas 511 is also fully interoperable with the Nebraska 511 System, so callers may also get complete information regarding Nebraska highways, and vice versa. Phone numbers are provided for roadway information in all other states adjacent to Kansas. Information provided includes road conditions, work zones, closed lanes, ramps or roads, incidents, major events, emergency travel information and weather, including route/segment-specific "now casts" and forecasts for up to six hours.

In 2009, KDOT launched KanDrive, <www.kandrive.org>, a one-stop gateway for travel information in Kansas and surrounding states. Content includes weather-related driving conditions, work zones, traffic incidents and weather information through a variety of communication media. It also provides travelers with other helpful travel information as noted below. Site features include:

- Interactive, online color-coded 511 Map (KanRoad re-branded to 511) that provides statewide, regional and metro area (Kansas City, Topeka/Lawrence, or Wichita) views.
- Camera views (both still and motion views for some locations)
- Current messages on Dynamic Message Signs
- Road Weather Information System (RWIS) map; National Weather Service Watches/Warnings and weather-related safety travel information
- Links to other helpful travel information, including metro traffic information for Kansas City and Wichita, data from roadway weather stations (RWIS), neighboring states' travel information, the Kansas Turnpike Authority (KTA), maps of the state, counties and cities, services for over-the-road truckers, and tourist information.

System Components: The KDOT Road Weather Information for Travelers System consists of the following:

- 511 phone system
- 511 Map <511.ksdot.org> that provides travel information similar to that provided on the 511 phone system
- KanRoad System within KDOT that provides the data for the 511 phone system and 511 Map

- KanDrive web site (a travel information portal) found on the KDOT general web site, <ksdot.org> or directly accessible from <www.kandrive.org>. This includes links to KC Scout, WICHway, Amber Alert, and the 511 Map.
- 511 Mobile Website <511mm.ksdot.org>
- Road Weather Information System (RWIS) maps that display atmospheric weather and pavement sensor data received from KDOT's remote processing units that are positioned strategically across the state.
- Wi-Fi/KIOSKS (planned) at KDOT Rest Areas, Travel Information Centers and State Parks
- Snow gates along I-70 that are currently operated manually when deployed. Prior to snow gates, barricades were utilized.

System Operations: The system includes road condition information gathered by KDOT staff. Typically this is the road superintendent, supervisor or office staff, culling information from equipment operators. Using staff at these levels has provided consistency that was lacking with initial efforts using equipment operators only.

KDOT is contracted with Meridian Environmental Technology to provide weather forecasts for the Kansas roadways on the 511 Phone System and with Telvent DTN to provide weather forecasts to Statewide KDOT field decision makers. Weather conditions include snow, ice, hail, thunderstorms, winter storms, fog and burning. Flooding is reported as a roadway event. Usage of the phone and website is year round, rather than solely focused on the winter.

All information provided on the 511 Phone System and 511 Map is fully automated, following initial manual data entry. Information is updated in the system within 5 minutes of data entry. Improvements to the system are based on information developed in the formation of a strategic plan, acknowledging resource constraints. Annual improvements, whether large or small, must be completed prior to the start of the winter season. This means testing must be completed by showing successful implementation of new features prior to October 1.

A KanDrive Support Plan has been developed to provide important procedures, documentation and consistent, efficient communications for KDOT, at both headquarters and District staff levels. The plan includes not only procedures during business hours, but also for after-hours operations and communications.

Transportation Outcome(s): The KDOT Road Weather Information for Travelers System is able to provide road conditions, weather, and lane or road closures due to construction, maintenance, or incidents. An informed traveler is able to make decisions that are safer while providing optimum mobility. Today's travelers expect this content and a range of delivery modes to be available to them in Kansas.

Implementation Issues: Initial deployment challenges included working with landline and cell phone companies across Kansas. Initial work included engaging the assistance of the Kansas Corporation Commission. This work was critical in the development of the 511 phone system.

Developing the "behind the scenes" weather condition-gathering system included the assistance of a Working Group, and significant contributions from field staff. This development activity has been modified so as to provide more consistency across the state.

Reduced staff at KDOT has produced instances where timeliness of reporting has been affected. For example, the person who plans to enter the conditions may have to assist with plowing operations, which diminishes time available for data entry. At the same time, Districts have aided neighboring Districts with manpower to mitigate effects of weather conditions and to post road weather-related information on the Dynamic Message Signs (DMS).

KDOT's urban Transportation Management Centers have aided in providing after-hour operations as needed for the cameras and DMS. This aids in quality and timeliness of the information. KC Scout's weather integration project has also provided invaluable assistance in generating emergency weather messages for DMS and in coordination with 511. It has further assisted with coordination between the National Weather Service and other state transportation partners and their communications.

The list of partners needed to implement this system was comprehensive, involving several bureaus within KDOT and partners from other agencies or organizations such as the Kansas Highway Patrol (KHP). KDOT has initiated several email distribution lists that can target certain groups within KDOT or other partner agency personnel to facilitate efficient communications with all extended team members, such as operations, technology, or public affairs.

Funding has been a challenge. Limited funding sources as well as funding amounts and resources are not consistent from year to year. Improvements to the phone system, the web site, the mobile applications and remote use such as at kiosks need to be broken out into phased improvements. Such a strategy may not be optimal from a development standpoint.

Finally, the partners at KDOT have learned that an important function of disseminating road weather information is to temper the expectations that motorists have in travel times.

Contact(s):

- Barb Blue, KDOT, Advanced Traveler Information/ 511 Program Manager, BBlue@ksdot.org
- Troy Whitworth, KDOT, Staff Maintenance Manager, Troy@ksdot.org
- Mary Beth Pfrang, KDOT, GIS Applications Project Manager, Marybeth@ksdot.org

Reference(s):

- 511, when called in Kansas, by either landline or cell phone, or 1-866-511-KDOT (5368) from anywhere in the U.S.
- 511 Map <511.ksdot.org>
- 511 Mobile <511mm.ksdot.org>
- KanDrive <www.kandrive.org>
- RWIS public site <http://www.ksdot.org/burcompser/generatedreports/weather.asp>
- KDOT Home page <www.ksdot.org>

Keywords: KDOT, KanDrive, 511, Road Conditions

Maryland DOT Emergency Truck Parking Portal

During inclement weather, and especially during severe snowstorms, drivers of commercial trucks are often in need of emergency parking areas or a safe haven to “ride out” the storm. As a result, the Maryland Department of Transportation (MDOT) in cooperation with the Maryland Motor Truck Association (MMTA) and the I-95 Corridor Coalition developed and implemented a program for emergency truck parking throughout the state of Maryland. The program includes the use of six (6) Park and Ride lots statewide to be used during heavy snow events as a safe haven for truckers. The development of a mobile application and web-based mapping to communicate the locations of all public facilities open for truck parking during emergency and non-emergency operations was also included as part of the program.

During the deployment process, the identification of emergency lots and enhanced use of available communication tools were proactive ways to alleviate future truck parking capacity issues similar to that experienced by the state of Maryland during the 2010-2011 winter season. To ensure safety on the state’s highways, it was determined that reliable and constant communication with truck drivers is imperative to ensuring efficient highway operations and maintenance during weather events. To accomplish this goal, Maryland developed the policy and set the process in motion by partnering with the state trucking association, police agencies, and local traffic and highway agencies.

The timeline from concept to project execution was less than two months, and truck drivers in Maryland now have designated places to stop during snowstorms. The six (6) Park and Ride lots across the state were selected as emergency lots for truck drivers traveling through Maryland by MDOT, Maryland Motor Truck Association, and the I-95 Corridor Coalition.

The total cost of the emergency truck parking application was approximately $100,000.

System Components: As mentioned above, the initiative includes the use of carefully selected Park and Ride lots, and mobile and Geographic Information System mapping applications. More information is available via Internet websites, and the page displaying emergency parking options for trucks can be viewed by going to the State Highway Administration (SHA) website at <http://sha.md.gov/pages/Emergencytruckparking.aspx?PageId=856>.

System Operations: The goal of the system is to help truckers going through Maryland make informed decisions during snowstorms. A new "mobile app" is available to inform truck drivers of the six (6) emergency lots, as well as other existing lots, to be used for commercial truck parking. Users can download this application to their phones, which will show a web-based map indicating the location of regular truck parking options (shown in green), and, on the same map, where emergency parking options are located (shown in blue) – example in Figure MD-1.

There are two (2) emergency lots in Montgomery County, one (1) in Harford County, one (1) in Baltimore County, one (1) in Frederick County, and one (1) in Prince George's County. The Park and Ride lots include facilities operated by the SHA and the Maryland Transportation Authority (MDTA), which will be responsible for removing the snow on the lots. The parking options can also be viewed from an interactive map online or as a PDF document that can be downloaded and printed.

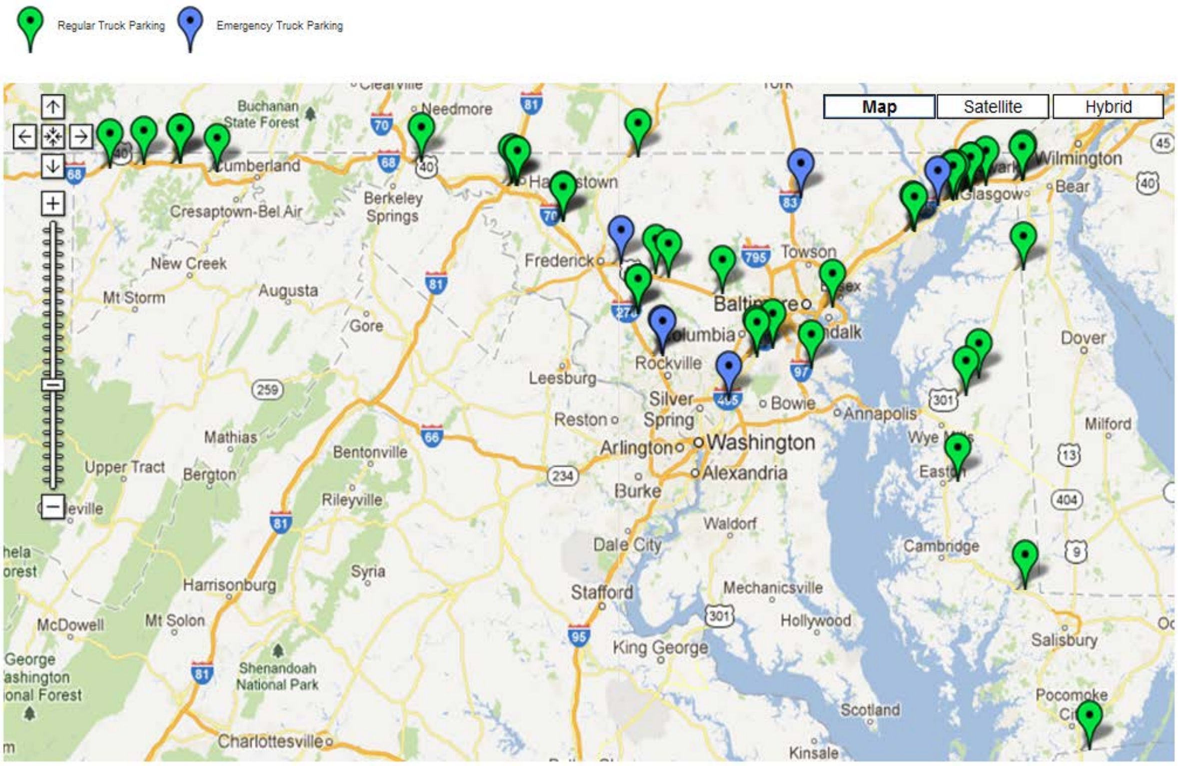

Figure MD-1. Maryland's emergency truck parking portal.

Transportation Outcome(s): During snowstorms of six (6) inches or more, tractor trailer drivers may use several commuter Park and Ride lots as a safe haven to "ride out" the storm instead of parking on highway ramps and shoulders, which present unsafe conditions for other highway users. This initiative provides an alternative for truckers traveling during heavy storms. The mobile application and web-based mapping tools provide the location of all truck parking areas available to truck drivers and company dispatchers, which facilitates preparedness when traveling in (and through) the state of Maryland.

Implementation Issues: One of the challenges faced during implementation was understanding the maintenance requirements of the public parking lots and determining whether truck parking would impede maintenance processes. The original list of potential emergency truck parking sites included 20 locations statewide, but facilities maintenance and geometric constraints reduced this number to six (6) sites to be used during the 2011–2012 winter season and thereafter. Another challenge was the inability to properly assess the results of the pilot program during the 2011–2012 winter season, which was largely due to the mild weather experienced in the Mid-Atlantic region.

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-

Reference(s):

- Maryland Emergency Truck Parking Portal website <http://sha.md.gov/pages/Emergencytruckparking.aspx?PageId=856>

Keywords: Truck parking, emergency truck parking, truck parking communication

Michigan DOT Measurement of Regain Time

The Michigan Department of Transportation (MDOT) spends roughly $100 million on winter maintenance each season. This represents approximately forty percent of its total maintenance budget. With this significant expenditure, there is a need to find an effective performance measure that will allow MDOT to evaluate the effectiveness of changes to its operations and to communicate this with the public.

For the winters of 2009-12, MDOT has collected speed information along the Interstate 96 (I-96) corridor from the Ionia County line eastward to the Oakland County line. Portable microwave sensors are used to detect traffic speed before, during and after a winter storm event. This information is then downloaded and graphs are prepared to show the average speeds over time. In addition, storm start times and end times are recorded by maintenance staff along with other information about the intensity and temperatures during the storm. The data are then used to illustrate regain time, which is the time needed after a winter storm event until vehicle speeds return to normal operating speeds.

System Components: The main components of the system are three microwave sensors that detect the speed of the traffic along the I-96 corridor. The sensors are spaced such that each is collecting information from a segment of interstate maintained by different MDOT road maintenance garages. Figure MI-1 illustrates a typical sensor apparatus.

Two of the sensors have a wireless signal that allows MDOT to remotely download the data from the office. The third sensor does not have Internet capability so the data is downloaded manually through a computer cable.

In order to sustain power to the sensors, each unit is hooked up to a Pointer Record (PTR) station that has a constant power source. During winter months, the solar panels do not generate enough power for the sensors to work. A power hook-up is needed.

System Operations: Two of the microwave sensors are mounted on portable trailers while the third is a portable unit that is attached to a power pole adjacent to I-96. The Microwave Vehicle Detection System (MVDS) High Definition Sensors use Wavetronix software for communications. This software is freely downloaded from Wavetronix with the purchase of the equipment.

Figure MI-1. Speed sensor apparatus to determine regain time.

Once MDOT receives the data it will need to be filtered through to match up with the storm events and analyzed. Some of this data is also shared with the Planning division since we collect all the lanes that we can along with speed, volume, occupancy, truck percentages, and 85% speeds.

Transportation Outcome(s): Speed seems to be one of the best indicators of effectiveness of MDOT's winter maintenance operations. The motoring public values the ability to move at posted speeds and have minimum delay. Assuming speed measurements are the best indication of regain time, the system can be scaled up to determine regain time for any areas with valid speed data. Speed data is already generated on most state freeways by the mobile phones of participating motorists. Additionally, other areas have various detection devices which capture speed data.

Implementation Issues: The use of portable traffic collection trailers is challenging given the winter conditions typically experienced in Michigan. MDOT found that the collection trailers would not adequately recharge with use of solar panels. The trailers had to be powered with a direct connection to the electrical power grid, eliminating many potential monitoring areas along the roadway. In addition, the cell phone connection used for data transmission has not always been reliable. These issues should be resolved once MDOT begins using speed data from mobile phones and other sources.

Contact(s):

- Will Thompson, Michigan DOT, Associate Region Engineer - University Region, 517-937-8672, thompsonw@michigan.gov

Reference(s):

- Foley, J., Thompson, W., and Warren, R., August 2009. "The Use of the 85 Percentile Speed Data as a Measure of Winter Maintenance Performance," presented at the 2009 National Rural ITS Conference <http://www.nritsconference.org/downloads/Presentations09/S5_Foley.pdf>

Keywords: regain, speed, microwave, wireless, winter, maintenance

Minnesota DOT I-35W Smart Lanes: Active Traffic Management

Minnesota's Smart Lanes is the brand name of the Active Traffic Management (ATM) system on I-35W in the Twin Cities Metro Area. The ATM system was deployed on Interstate 35 West (I-35W) in two phases between 2009 and 2010. The original system covered sixteen miles of I-35W south of Minneapolis and was extended by two miles in 2011. A new eight-mile section of ATM is being installed on Interstate 94 (I-94) between downtown Minneapolis and downtown St. Paul and was scheduled to be activated in the summer of 2012.

Figure MN-1.
ATM signals on I-35W.

ATM consists of electronic signs over lanes of traffic (see Figure MN-1) to provide real-time information to help motorists make informed decisions about their commute. The signs display information about road conditions to improve traffic flow, reduce congestion and improve safety.

The signs are illuminated during traffic incidents to indicate whether lanes are open to traffic. This use of technology will enhance safety and improve the flow of traffic by providing motorists information about the conditions within their lane (and alert them to what is ahead). The information provided by these overhead lane signs will be real-time, designed to help motorists navigate safely through traffic. The ATM system was modeled after similar systems in Europe that have been proven effective at reducing collisions and improving traffic flow.

The ATM system is operated out of the Regional Transportation Management Center (RTMC). The RTMC is a co-located operations center housing Minnesota Department of Transportation (MnDOT) freeway management staff, Freeway Incident Response Safety Team (FIRST) dispatch, MnDOT arterial management staff, MnDOT maintenance dispatch, and State Patrol metro area dispatch. From the RTMC, MnDOT operates a Freeway Management System (FMS) covering over four hundred miles of Twin Cities Metro Area freeways including the I-35W ATM corridor. The system includes loop detection, dynamic message signs (DMS), ramp meters, cameras, and fiber optic communications. The existing FMS provided the backbone for the ATM system deployed on I-35W.

MnDOT has a freeway traffic management system software known as Intelligent Roadway Information System (IRIS). IRIS was developed in-house to communicate and control loop detectors, DMS, and ramp meters. The software was expanded to control the ATM system.

System Components: A series of overhead signs known as Intelligent Lane Control Signals (ILCS) above each lane on I-35W are used to inform drivers of upcoming conditions or controls in place. Overhead signs are used to indicate which lanes are closed to access, blocked because of a crash or obstruction, and which adjacent lanes are impacted by such events. The ILCS are used to post advisory speed signs, warning travelers to slow in anticipation of stopped traffic ahead.

The ILCS are located along northbound and southbound I-35W from I-35 to the I-35W split with Highway 65. Spacing of the signs is approximately one-half mile apart. The exact spacing is based on relations to bridges, existing signs, sight lines and budgets.

Existing overhead signs and High Occupancy Toll (HOT) lane signs are incorporated on same sign structures as ILCS. Sign structures are placed in accordance with sign spacing requirements. Sign structure placement will be determined in the design stage.

At key locations along I-35W, ILCS are used to inform drivers of closed lanes and/or recommended speed limits. The managed lane control system essentially serves four key purposes:

- Inform drivers when the left lanes are open to High Occupancy Vehicle (HOV) and/or HOT lanes;
- Inform drivers of advisory speed limits (when necessary) in order to slow traffic that is approaching stopped traffic (At this time, uniform speeds are posted across all lanes. MnDOT has not ruled out the idea of varying speeds in lanes and may opt to implement this in the future);
- Inform drivers of lanes closed (such as when dynamic shoulder lanes are closed or when general purpose lanes are closed due to a crash or stalled vehicle); and
- Inform drivers of hazards such as standing water or debris on the roadway and encouraging travelers to merge away from the hazardous lanes.

The signs over each lane are used to display one of eight messages, as shown in Figure MN-2 and summarized as follows:

1. Blank (black sign) – to be used as the default display. To be effective ILCS messages should be timely, accurate, and reliable. Displaying other default messages would distract from normal signing and would dilute effectiveness when really needed.
2. Red 'X' – to be used to indicate that the lane is closed to traffic or has an incident, crash or other obstruction. Emergency vehicles and other incident responders would be allowed to use the lane to respond to blocking incidents quicker.
3. Advanced Yellow 'X' – to be used to indicate that the lane will be closing one mile ahead because of an incident, crash, or other obstruction.
4. Merge with moving chevron – to be used to indicate traffic should merge right or left as the lane is closed ½ mile ahead because of an incident, crash, or other obstruction.
5. Yellow Flashing Arrow – to be displayed on lanes adjacent to a closed lane (each Red 'X' will be surrounded by yellow flashing arrows.)
6. Green Arrow – to be displayed during an incident above those lanes not affected by the incident (a red 'X' will be above the lane with the incident, flashing yellow arrows above adjacent lanes, and green arrows above other lanes.)
7. Advisory Speed – displayed as a two-digit number with 'MPH'.

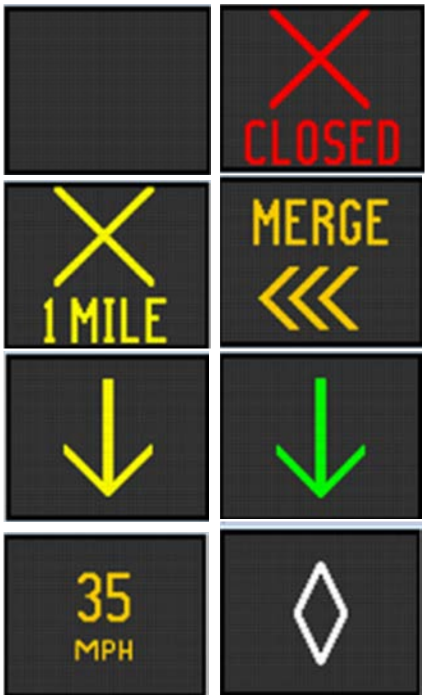


Figure MN-2. Possible display messages above traffic lanes.

8. White diamond – to be used to indicate lane use as exclusively for vehicles with high occupancy.

System Operations: The managed lanes are controlled by RTMC operators from within the RTMC. Operators have full authority to select from available messages, after events are verified.

The display of lane advice depends on the location of any lane obstructions and the resulting Red ‘X’ signal indicating lane closure. Advanced warning messages are posted on all signs located upstream of the blockage within a distance of at least one mile. As motorists approach a closed lane they will encounter an Advanced Yellow ‘X’ sign one mile before the closure. The next sign will display a ‘Merge with Arrow’ within a half mile of the actual Red ‘X’ sign over the lane that is closed. This is to ensure that travelers have advanced warning of the closure before reaching the incident. Further upstream, the signs will display an automated advisory speed posting which will change based on real time traffic conditions. This is explained in the next section.

When display signs are posting either a Red ‘X’ or yellow flashing arrow message, all other signs will display a green arrow. Figure MN-3 shows an example of signing for a crash blocking a lane and activating Advisory Variable Speed Limits.

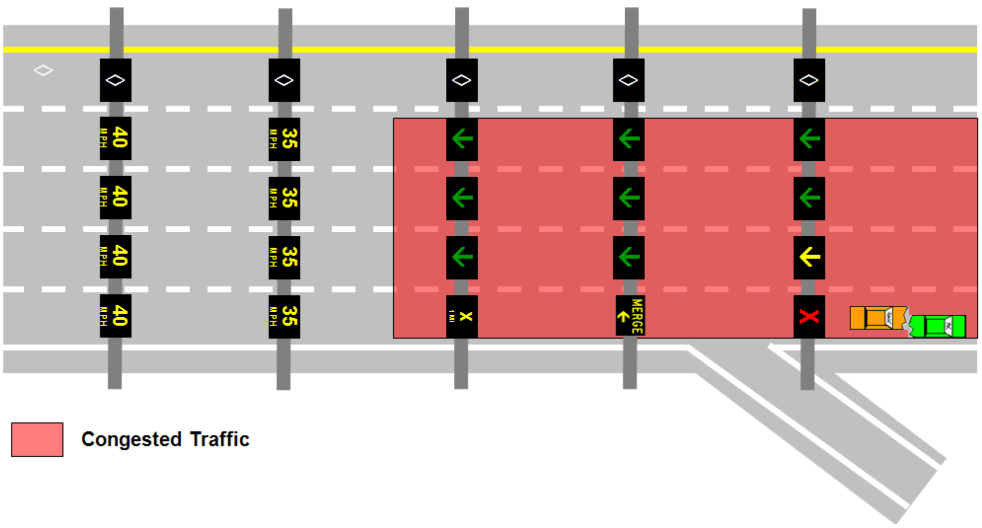


Figure MN-3. Example of display of intelligent lane control signals during an incident.

The selection of advisory variable speed limits (VSL) is computed by an algorithm developed by the RTMC and the University of Minnesota - Duluth. RTMC operators have the option to override the calculated advisory speeds or to accept the recommendation and verify the posting of the message.

The goal of the advisory VSL system is to mitigate shock wave propagation from downstream bottleneck by gradually reducing speed levels of incoming traffic flow. Figure MN-4 illustrates how speed

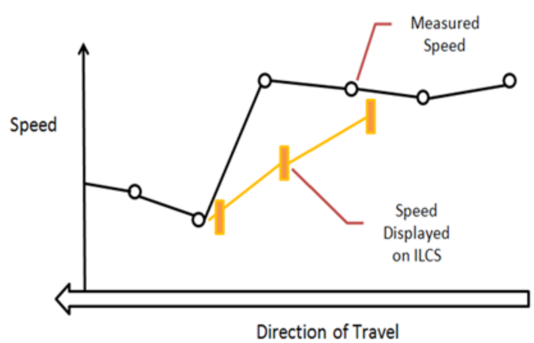


Figure MN-4. Display of advisory speed limits on DMS as it relates to freeway speeds.

data is collected through traffic sensors on the roadway at point locations shown as black circles on the chart. Without advisory VSL, vehicles approaching congested traffic are forced to change speeds within a very short distance leading to sudden stopping and possible rear end collisions. The advisory speed limits are posted to allow for a more gradual deceleration between upstream free-flowing traffic and congested traffic. The speeds displayed on the ILCS would gradually reduce traffic speeds as shown by the yellow boxes in the figure.

As congestion levels develop, two or three sets of signs prior to the congestion display an advisory speed limit based on the algorithm depending on what the speed differential is between upstream and downstream traffic. Speeds can be posted up to 1.5 miles upstream of congestion.

Advisory speeds posted to the overhead signs change by no more than five miles per hour (MPH) with each change in speed, and can be updated every thirty seconds if traffic conditions warrant. The minimum advisory speed displayed is thirty MPH and the maximum advisory speed displayed is fifty MPH. If the current speeds on the roadway are below thirty MPH the signs will go blank.

Transportation Outcome(s): This use of technology will enhance safety and improve the flow of traffic by providing motorists information about the conditions within their lane (and alert them to what is ahead).

Implementation Issues: There are currently several implementation issues that MnDOT is resolving, particularly with regards to expanding the ATM from incident-based traffic management to weather-based traffic management. Additionally, dynamic lane striping and signaling was a challenge in implementing the full system.

MnDOT is currently researching how to modify the advisory speed limit during inclement weather. Currently the system uses a constant deceleration rate to determine advisory speed limit values. Observations of the system have found that the preferred deceleration rates may be different during different kind of weather conditions. An observation of the system found that the maximum speed value needed to be adjusted due to weather conditions. Historically, the maximum speed limit of the system was capped at 5 MPH less than the posted speed limit. This value was changed to a maximum of 50 MPH for all corridors when it was found that the system would deploy 60 MPH on the corridor during major snow events. MnDOT is working to develop new techniques for the advisory variable speed limit system during weather events that would automatically adjust the deceleration rate and the maximum speed value based on real-time weather conditions on the corridor. The VSL system would utilize rain sensors on the corridor to inform the system of what type of precipitation was falling and at what rate.

Along the southern half of the I-35W corridor there are sections where the left lane of traffic was shifted onto the inside shoulder by two feet to allow for a buffer zone between the new HOT lane and the general purpose lanes. This inside shoulder was originally designed to allow for some ponding during heavy rainfall. Now that traffic is shifted onto these shoulders, there is a potential for hydroplaning during heavy rainfall as the shoulder area begins to fill up with water. MnDOT is investigating the use of rainfall sensors to automatically deploy either a warning message or advisory speed limit over this lane during these conditions.

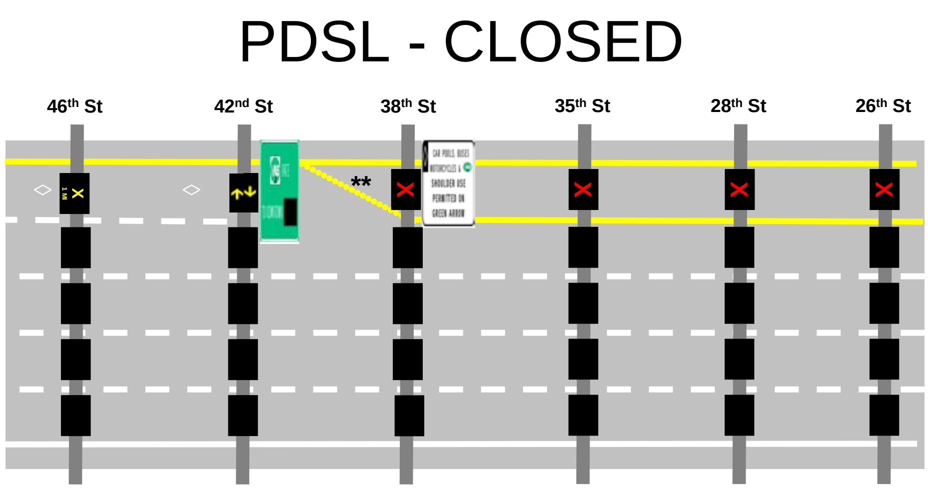
The physical width of the stretch of I-35W northbound from 42nd Street to downtown limits the number of lanes and shoulders. The I-35W ATM system includes the concept of a dynamic shoulder lane in the left-most lane along this stretch of road. This left-most dynamic shoulder lane operates as a

- priced dynamic shoulder lane at times when the adjacent stretch of I-35W is operated as a HOT lane,
- priced dynamic shoulder lane at times when the capacity is needed, and
- shoulder when needed.

The dynamic shoulder lane is separated from the general purpose lanes by a single solid yellow stripe. An additional yellow stripe was placed along the center median barrier to improve visibility. A static sign is placed at the beginning of the dynamic lane (Figure MN-5).

Figure MN-5. Static sign for dynamic shoulder lane.

A computer simulation of the dynamic shoulder lane entrance indicated that MnDOT needed to enhance the pavement marking to inform motorists whether the priced dynamic shoulder lane (PDSL) was opened or closed. For this reason it was determined that in-roadway lighting was best suited for this project. In the transition zone, an LED in-roadway lighting system was developed to alert traffic to merge right when the PDSL is closed (Figure MN-6). The LED lights were the same color as MnDOT's standard yellow striping and were dimmable for night time driving. The in-roadway lighting was able to be changed to a white LED light when the PDSL is open that will extend the existing white skip striping into the dynamic shoulder lane (Figure MN-7). After two seasons, the LED in-roadway lighting system failed due to corrosion in the power connections within the LED units. Analysts compared violation rates of the PDSL merge area with and without the in-roadway lighting and found no distinguishable difference in the amount of violators in the PDSL without the lights. Due to the high cost of replacing the system, MnDOT is not planning to bring the LED in-roadway lighting back into service.



**** The dotted yellow line between 42nd and 38th Street represent the in-road lights. The lights will be spaced to simulate the painted yellow edge line.**

Figure MN-6. Striping and signing with PDSL closed.

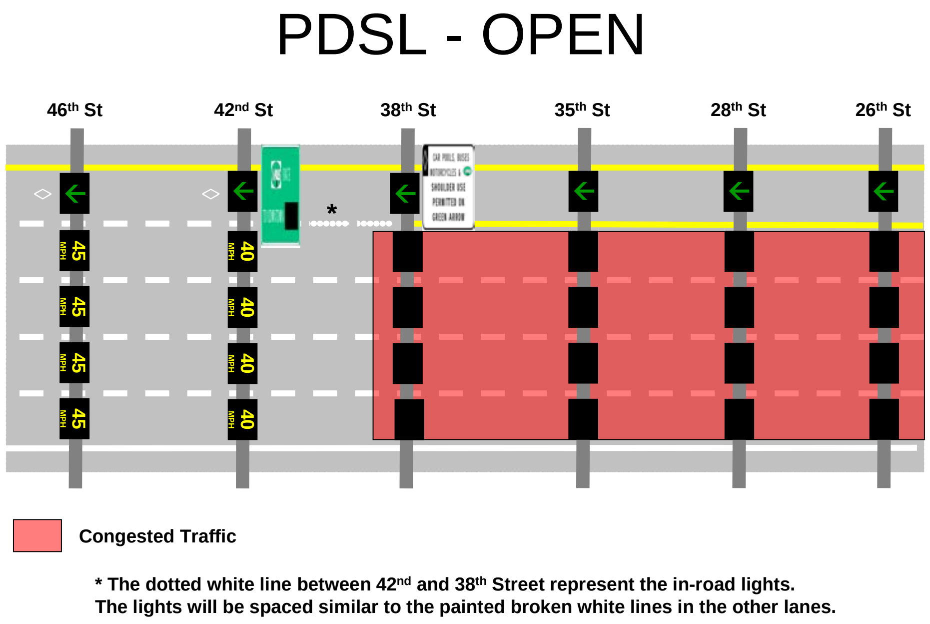


Figure MN-7. Striping and signing with PDSL open.

Lane widths for the dynamic shoulder lane and the general purpose lanes vary from 11 feet to 12 feet. Between the dynamic shoulder lane and the general purpose lanes is a two foot buffer. Reaction distance from the dynamic shoulder lane to the center median barrier varies from 2.5 feet to six feet. Static signing as shown in Figure 4 together with intelligent lane control signals will designate when the shoulder lane is open to traffic.

After the first several snowfalls, MnDOT Maintenance staff recommended that the dynamic shoulder lane remain open during snow and ice events to help spread the de-icing material throughout the lane. During off-peak periods when no vehicles were present on the dynamic shoulder lane, de-icing materials were not able to be spread out by passing vehicle traffic thus leaving icy patches across the lane. By leaving the lane open to traffic, just enough vehicles used the lane to keep de-icing materials spread out and keep the lane free of ice.

Contact(s):

- Brian Kary, Freeway Operations Engineer, 651-234-7022, brian.kary@state.mn.us

Reference(s):

- Minnesota Smart Lanes website <http://www.dot.state.mn.us/smartlanes/>

Keywords: Dynamic Message Sign, traffic management, incident management, weather management, incident response, intelligent signage, variable speed, variable lane configuration, advisory speed, dynamic pricing, dynamic shoulder

Montana DOT Equipment Vehicle Management System

The Montana Department of Transportation (MDT) developed an Equipment Vehicle Management System (EVMS) to provide a comprehensive solution for managing, monitoring, and controlling fleet operations for both the State Motor Pool and the Equipment program. In developing the system several essential principles were considered, including: preserving the fleet through timely servicing; conducting preventive maintenance and repairs; recording equipment rental rates and financial information; identifying impending fleet repairs to reduce downtime; maintaining an equipment replacement log that identifies equipment age and maximum lifetime; ensuring efficient and economical use of the fleet and manpower; and purchasing vehicles and equipment that are multifunctional and that will support maintenance, engineering, construction and other user requirements. EVMS is utilized by 16 mechanic shops statewide.

System Components: The EVMS is comprised of four modules: Labor Equipment; Materials; and System, as software application window illustrated in Figure MT-1.

Figure MT-1. Montana DOT EVMS main application window.

The Labor Module performs all functions related to the assignment of personnel. Capabilities include transferring employees across administrative units, setting up crews, defining a calendar from which to create time cards, and the creation of administrative work orders.

The Equipment Module handles any and all equipment activity. The functionality includes purchasing, repairing, fueling, servicing, and sale/salvage for all equipment.

The Materials Module provides a system for the management of material resources. These include capabilities for tracking material stockpiles, purchasing new supplies, managing the warehouse inventories, and requesting materials from other administrative units.

The System Module controls settings of the software and maintains settings for system interfaces (like fuel transactions, for example).

System Operations: MDT mechanics maintain equipment through preventative measures and necessary repairs. When using the EVMS to catalog work performed, the mechanic selects the Equipment Module, and specifies the particular issue and notes an in-house repair. To establish a repair order, the mechanic selects the unit/vehicle number and proceeds to process the repair by selecting the work activity, entering labor hours per activity, listing parts used, and checking warranties. Down time is also recorded. Once the repair order is completed the mechanic signs-off and it is ready for the approval of the shop superintendent.

Transportation Outcome(s): The EVMS system manages all aspects of maintaining and preserving the State Motor Pool fleet and Equipment. The benefits of utilizing EVMS are digital records of inventory, scheduling and tracking repair orders, tracking labor and materials cost, "real time" report utilization, tracking of warranties, recording fuel & mileage history, and online scheduling of statewide motor pool reservations. By providing these types of data, the system can maximize equipment lifetime, decrease maintenance and repair costs, and increase vehicle utilization for maintaining and constructing state roads.

Implementation Issues: The EVMS system version 3.4 was implemented in March 2004. Since its implementation the application has undergone minor enhancements. MDT is currently still using client/server architecture for the system. A project is now underway to upgrade the existing EVMS to a web-based system, which will create one location and one access point for the entire program.

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- Walt Kerttula, Supervisor and Financial Specialist, 406-444-6319, wkerttula@mt.gov

Reference(s):

- Fleet and Equipment Software Solution, AgileAssets website <http://www.agileassets.com/solution-sets/fleet-equipment/>

Keywords: Fleet Management Systems, Fleet Software, DOT Asset Management

Montana DOT Traveler Information System

The Montana Department of Transportation (MDT) provides extensive traveler information to Montana's driving public. This information includes winter roadway conditions, highway construction projects, road closures, accident and incident reports, load and speed restrictions, and a variety of other traveler information.

System Components: The traveler information system consists of a host of media including the Internet, Montana's 511 phone service, highway advisory radio systems, road weather information stations (RWIS) and cameras, and dynamic message signs.

Figure MT-2. Components of traveler information system.

System Operations: Detailed information is provided by field personnel and then entered into a database by division area office staff. The database runs on an Oracle platform and information is disseminated to the web and phone service. The dynamic message signs are controlled by using a specialized control software package.

Transportation Outcome(s): Traveler information needs continue to grow and change as new technologies become available. The information MDT provides is utilized by an increasing number of people, with more than a million calls to our 511 system since deployment in 2003 and more than 14 million hits on the website annually. By providing travelers with accurate information through various means it allows them to make informed travel decisions. The benefits include avoiding excessive delays, being prepared for adverse weather, and determining what route best meets their needs.

Implementation Issues: One ongoing challenge with the system is providing accurate and timely information. Another open question is the cost-effectiveness of utilizing portable hardware versus permanent hardware for data collection and dissemination of information. Finally, software integration amongst products built by various manufacturers has been another challenge.

Contact(s):

- Brandi Hamilton, Business Operations Supervisor – Maintenance Division, 406-444-0468, brhamilton@mt.gov

Reference(s):

- "Road Weather Information System", MDT Traveler Information Website, <www.mdt511.com>

Keywords: traveler information, winter conditions, highway construction, road closures, accident reports, incident reports, load restrictions, speed restrictions

New Mexico DOT Dust Control System

Dust storms occur quite frequently in New Mexico. They are the result of when powerful winds pick up large quantities of very dry (and thus, easy to particulate) exposed surface soil and obscures visibility as depicted in Figure NM -1.

The low visibility detection system installed along Interstate 10 (I-10) at the southwest corner of New Mexico in what is called the La Playa Region (ancient dry lake bed). This stretch of I-10 is routinely closed due to dust storms, some of which have been fatal in the past. The system was installed at the end of 2011 as part of a technology transfer research project with New Mexico State University acting as the principal investigator.

Figure NM-1. Poor visibility on I-10 due to dust storm.

The research project is ongoing and currently in the evaluation phase (expected to continue for two years). The purpose of the system is to work in a coordinated fashion with other ITS deployments along I-10 (Dynamic Message Signs [DMS], Closed Caption Televisions [CCTV], and Highway Advisory Radio [HAR]) to assist in incident management (including network surveillance and information dissemination) when dust storms occur. The scope of the installation is limited to the immediate vicinity of the La Playa Region at mile points 10 and 11 of I-10. The cost of two installations was approximately $200,000. The installations began in October and were completed in November of 2011.

System Components: The NMDOT La Playa RWIS system consists of the following specific equipment:

- Ultrasonic Wind Sensor
- Present Weather / Visibility Detector
- Air Temperature and Humidity Sensor
- Solar Radiation Shield
- Barometric Pressure Sensor
- Remote Processing Unit (Battery Backup)
- 30-foot collapsible (folding) tower
- Video Monitoring System
- Wireless modems

Figure NM-2. La Playa I-10 RWIS mile post 12.

System Operations: System relies on web-interface for access. Collected data includes:

- Air Temperature
- Dew Point Temperature
- Wind speed
- Max Wind speed
- Precipitation with rolling averages for 1, 3, 6, and 24 hours
- Relative humidity
- Visibility

Data is managed, stored and accessed via Vaisala Inc. Navigator System.

Power service is via standard secondary power (no solar).

The System can provide notifications to various stakeholders (NMDOT Maintenance and Dispatch Staff, Law Enforcement) when parameter values for wind speed or visibility are exceeded. These notifications are used to place responders into high alert on the potential for dust storms. Should one occur, this system will be used in conjunction with traveler advisories via DMSs, HARs and 511 / Website and network surveillance systems at pre-determined closure points.

Transportation Outcome(s): The La Playa I-10 RWIS system is still in the evaluation phase of the research project. Benefit and Cost criteria has been established and will be collected over the next two years to determine if the system is suitable and feasible for a wider deployment.

Implementation Issues: Bringing power to each of the remote installations has been the most substantive element of concern.

Contact(s):

- Ruinian Jiang, Principal Investigator and Evaluator for NMSU, 575-646-1506, rjiang@nmsu.edu
- Scott McClure, P.E., Chief of NMDOT Research Bureau, 505-798-6739, Scott.mcclure@state.nm.us
- Charles Remkes, P.E., Manager NMDOT ITS Operations, 505-222-6554, Charles.remkes@state.nm.us

Reference(s):

- Dust Storm Mitigation White paper by NMDOT <http://www.dot.state.nm.us/content/dam/nmdot/Research/Profile_Sheet_-_Dust_Storm Mitigation.pdf>

Keywords: Dust Storms Low Visibility Warning System

Pennsylvania DOT Interstate Restriction System

In February 2007, a winter storm comprised of rain, ice and snow caused multiple accidents on Pennsylvania's interstate highway. Twenty five percent of interstate routes were closed for extended periods of time. Many motorists were stranded along interstate corridors. Local and state resources were diverted from their primary duties during the storm to remove motorists from traffic queues and to manage detour routes. This combination of incidents prompted the Pennsylvania Department of Transportation (PennDOT) to deploy a management system for temporary speed restrictions and vehicle restrictions along the interstate. The goal of this effort is to reduce accidents stemming from inclement weather on the state's limited access highways.

System Components: Pennsylvania's interstate system is divided into regional geographic sections so only impacted sections of the interstate system are restricted in response to various weather conditions. The system was designed to utilize the state's existing and planned ITS infrastructure, meaning it was "no cost" to implement. When the system is activated, PennDOT utilizes variable message signs, highway advisory radio, 511, local media, Twitter and e-mail notification to inform the traveling public and commercial vehicle operators of the restrictions. PennDOT intends to expand its means of notification through the use of various social media in 2012-13.

System Operations: The PennDOT Interstate Restriction system (Figure PA-1) consists of a managed plan to implement vehicle restrictions. The system is designed to increase and decrease restrictions as adverse weather conditions change. When certain weather conditions are reached, the first measure is triggered, warning motorists of winter road conditions. As conditions worsen, speed restrictions are imposed. Next, certain types of vehicles are barred from the interstate. If conditions are severe enough, eventually all interstate traffic is restricted.

(In Figure PA-1, Note that "Normal Operations" implies routine snow removal operations. If a restriction is not enacted, then standard snow removal operations continue. Also, the "Interstate Conditions" are defined as: 1 – clear; 2 – wet with freezing conditions; 3 – snow and/or slush covered; 4 – snow packed/significant snow cover; 5 – icy; 6 – impassable.)

During large-scale weather or "All-Hazard" emergencies, PennDOT operates under a uniform Incident Command System. The PennDOT Area Command center is located in the State Emergency Operations Center. Other representatives from impacted state agencies are also present. This coordination provides one location for coordinated incident response and planning between PennDOT, the Turnpike Commission, State Police, the National Guard and the State Emergency Management Agency.

At the onset of an inclement weather event, PennDOT provides advanced warning of hazardous road conditions through variable message signs and highway advisory radio. PennDOT Engineering District Incident Command Centers coordinate with the Area Command as weather conditions deteriorate on reduced speed limits and restrictions in the impacted region. Engineering District Incident Command Centers review road conditions, weather forecasts and traffic volumes to determine if additional restrictions are necessary. Forecasts of high winds, icing or blizzard conditions prompt planning for vehicle type restrictions and can lead to total interstate closures.

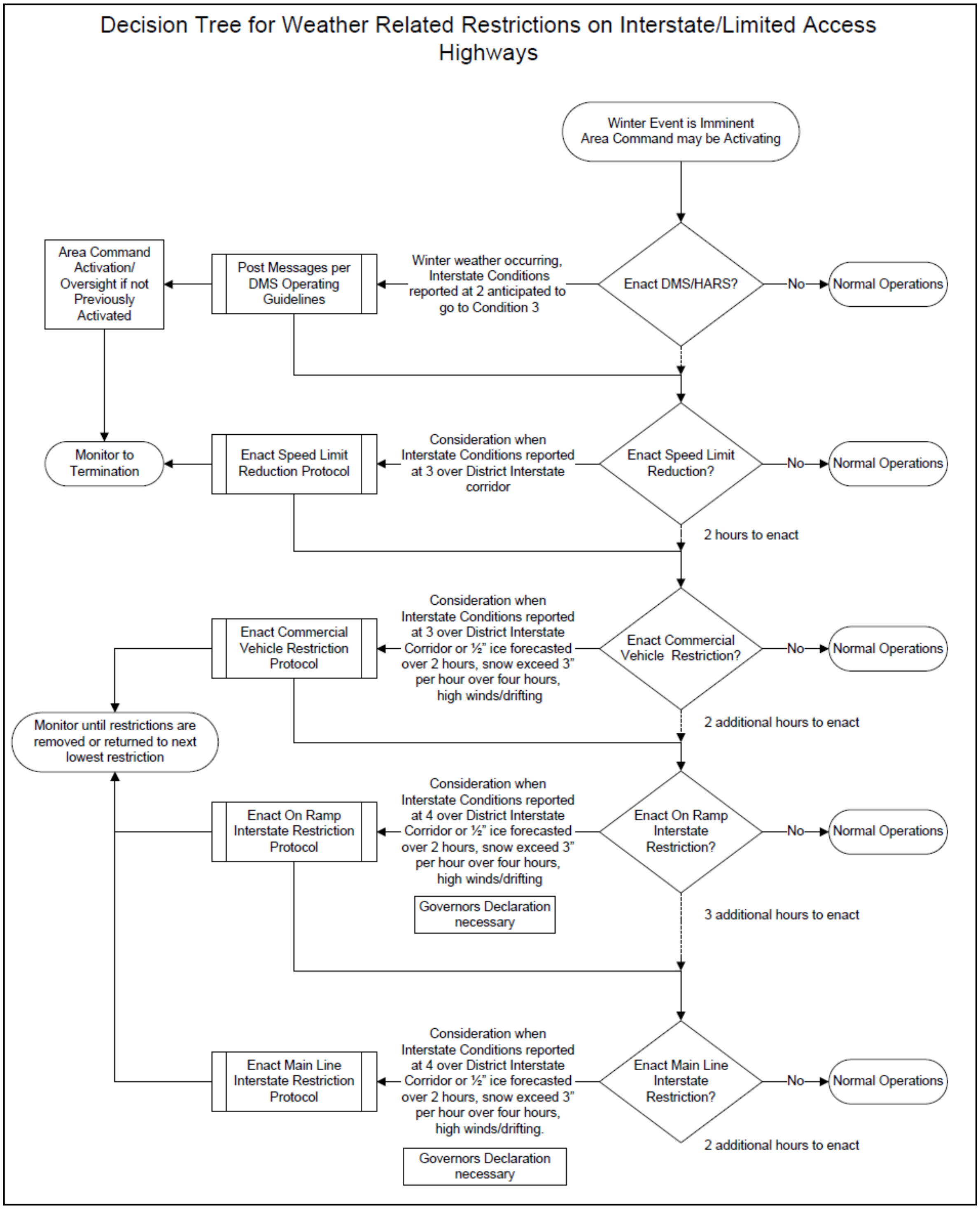

Figure PA-1. Interstate restriction flow chart.

Transportation Outcome(s): Historically, adverse weather accidents on the interstate involve large commercial motor vehicles, requiring lengthy closure times given the weather conditions. Critical resources are diverted to detour efforts or providing safety for motorists in the resulting traffic queue. The Interstate Restriction system has dramatically reduced vehicle accidents during inclement weather events. PennDOT's Traffic Engineering and Highway Safety Division performed an engineering study and confirmed that in winter storms of equal magnitude fewer accidents occurred when 45 mph restrictions were in place. The reduction in accidents decreases traffic disruptions which allow PennDOT to efficiently continue maintenance operations on interstates. While the system was primarily developed for winter weather, speed limit reductions and specific commercial vehicle restrictions have been implemented successfully for high wind events like Hurricane Irene.

Implementation Issues: The primary implementation issue is providing adequate notification of interstate restrictions to the motoring public and in-transit commercial motor vehicle operators. PennDOT continues to expand Intelligent Transportation System (ITS) infrastructure, coordination with surrounding states' Traffic Management Centers, 511 systems, and the use of social media to provide interstate restriction notification to motorists. Also, when implementing commercial motor vehicle restrictions, concerns with commercial vehicle parking have been identified. PennDOT is developing global diversion routes to provide restricted traffic with alternate routes of travel around restricted corridors. PennDOT continues to work with the Pennsylvania Motor Truck Association to provide advanced warning of interstate restrictions to facilitate their members' dispatch planning.

Contact(s):

- Charles C Goodhart - PennDOT, Director, Bureau of Maintenance and Operations, 717-787-6899, cgoodhart@pa.gov
- Jason Norville - PennDOT, Section Chief, Winter Operations, 717-787-7004, janorville@pa.gov
- Jonathan Fleming - PennDOT, Section Chief, Emergency and Incident Management, 717-772-1771, jonfleming@pa.gov

Reference(s):

- Goodhart, C., "Lessons Learned and Next Steps to Effective Winter Storm Management," http://www.nritsconference.org/downloads/Presentations10/C1_Goodhart.pdf, presented at the 2010 National Rural ITS Conference, August 2010

Keywords: adverse weather, emergency management, weather information, speed limit restriction, incident management, traffic management, speed management, advisory speeds

South Carolina DOT Hurricane Traffic Evacuation Operations

South Carolina has an extensive network of designated evacuation routes for motorists to use should there be a need to vacate coastal areas for a hurricane. There are twelve major evacuation routes, each approximately 100 miles long. From these twelve, one interstate and three primary routes can be reversed for higher evacuation traffic capacity leading away from the coast. All evacuation routes are “loaded” with vehicles from a designated area of the coast. Traffic is directed by signs and law enforcement to ensure maximum utilization of each route and to avoid over capacity of others. High coastal population numbers will present a capacity challenge to most routes used for evacuation. By aggressively managing traffic flow during evacuation, a higher probability of minimal drive times and reduced frustration for motorists will be realized.

System Components: Intelligent Transportation System (ITS) elements play an integral role in the evacuation operations. All ITS infrastructure including Incident Responders, permanent and portable changeable message signs, traffic cameras, highway advisory radios, congestion sensing devices, and 511 Travel Info have been developed since Hurricane Floyd in 1999. The South Carolina Department of Transportation’s (SCDOT) traffic counters were in place prior to Hurricane Floyd and remain a valuable part of evacuation traffic evaluation today. Traffic camera video, congestion monitoring abilities, and traffic count data are used by the State Emergency Operations Center (SEOC) Emergency Traffic Management Unit to monitor and alter operations on evacuation routes as needed by the South Carolina Highway Patrol (SCHP) and SCDOT. The video viewed at the SEOC is fed through dedicated fiber optic cable from the State Traffic Management Center (STMC). This offers an extra measure of reliability and allows camera control of all SCDOT’s 302 video cameras statewide. A large number of these cameras are on coastal evacuation routes and are used daily to manage high traffic volumes in these areas.

SCDOT’s Incident Responders, known as the State Highway Emergency Program (SHEP), are the other critical element of evacuation operations. During hurricane evacuation operations, they assist in keeping key evacuation routes in Myrtle Beach, Charleston, and Columbia free of incidents that lead to traffic congestion. SHEP units from northern areas of the state assist in covering the entire length of reversed Interstate 26 (I-26) from Charleston to Columbia (100 miles) assisting to clear incidents that may impede traffic flow. Figure SC-1 is an aerial view of the termination of the evacuation reversal of I-26 near Columbia.

System Operations: SCDOT and SCHP have adopted the Incident Command System (ICS) as the operational framework used for coastal evacuation. ICS will be used in all situations where Emergency Traffic Management is necessary throughout the state for adverse weather, man-made disasters, and so forth. ICS organization and concepts have been used successfully by fire services for decades and have proven themselves to be the best framework for all emergency services and disaster relief.

SCDOT and SCHP have jointly developed ICS Incident Action Plans (IAP) to address actions associated with each hurricane reversal route. IAPs have been developed for all evacuation activities along all coastal exit routes. Public response partners such as local law enforcement, fire services, emergency medical services, the law enforcement branch of the State Natural Resources Division, the State Law Enforcement Division (SLED), civil air patrol, National Guard, and county emergency management entities are incorporated in each IAP. This development effort has taken a substantial amount of detailed work by the parties involved.

The IAP concept has been tested through many Table Top Exercises (TTX) conducted with state and local partners and through a full-scale exercise last year for the simulated reversal of I-26 from Charleston to Columbia. The full-scale exercise entails bringing all assets, those of law enforcement and SCDOT traffic control devices, to each interchange on I-26 from Charleston to Columbia. The Interstate is not actually reversed but everything necessary to do so is at the roadside. The IAP concept is continuously exercised with the state's annual full-scale simulation of the evacuation operation and the manning of evacuation traffic control points. During the exercise, simulated traffic problems will be presented to field personnel for mitigation by using IAP procedures identified through yearlong training.

All evacuation routes are planned to provide lane continuity. For example, at major intersections or other transition points, two lanes will transition to two lanes and not be reduced to one. However, there are some exceptions as some roads are not wide enough to accommodate such continuity. There is extensive use of static traffic control devices (cones, barricades, etc.) and law enforcement personnel when a lane reversal is employed.

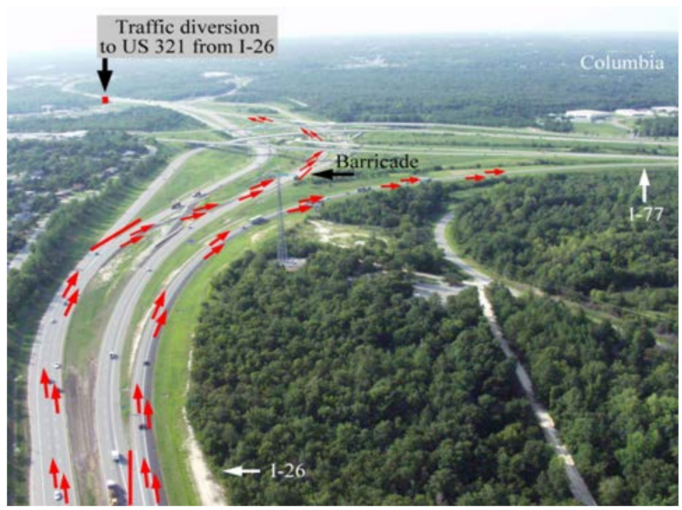

Figure SC-1. Aerial view of I-26 near Columbia, SC where 100-mile evacuation reversal is terminated.

To aid in the goal of lane continuity, SCDOT has employed ITS technology to its maximum advantage along evacuation routes. Further SCDOT has instigated the use of ICS/IAP procedures to maximize operational efficiency and has assured sound, logical communications protocol during hurricane events.

Transportation Outcome(s): The growing number of permanent residents within fifty miles of the coast and the high number of tourists that visit the coast each year during hurricane season motivate SCDOT to provide safe, effective evacuation operations. The coastal access road system has not kept pace with the population growth – only minor traffic capacity improvements have been made in the last forty-five years. This combination of constrained road system and high population makes it imperative that the maximum traffic capacity is achieved during evacuation events.

The new ICS is paying many dividends in its simplicity, concise instruction and adaptive flexibility. Stakeholders and the public have realized the benefits accruing to them through this cooperative framework and periodic review process. The current initiative represents the state's best efforts to protect the public when a hurricane threatens the coast. SCDOT is prepared for evacuations but will continue to evaluate yearly and improve as resources permit.

Implementation Issues: Two implementation issues of the state's evacuation plans are availability of evacuation routes and appropriate signage along those routes. The SCDOT and SCHP assess all routes in the field yearly to ensure evacuation signage is in place. Also, evacuation routes are altered if needed during the yearly assessment.

Prior to hurricane season, meetings are held to reexamine emergency traffic flow procedures, confirm or alter staffing at traffic control points along the routes, and verify the ITS components used for hurricane evacuation traffic. These meetings occur in each of the state's three major coastal evacuation areas with county emergency management officials, local law enforcement, SCDOT, SCHP Troopers, fire services, Emergency Management Services, and the National Guard in attendance.

In 2012 the ICS/IAP concept for evacuation management was presented in the regional meetings with all partners. Additional meetings were held by SCDOT and SCHP to assure a familiarity amongst stakeholders during transition to the ISC approach. It is very important that all involved embrace ISC and understand their role in the IAP.

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Reference(s):

- South Carolina Department of Transportation <http://www.scdot.org>
- South Carolina Emergency Management Division <http://www.scemd.org>

Keywords: Hurricane, emergency traffic management, Incident Command System (ICS), Incident Action Plan (IAP), Intelligent Transportation System (ITS), traveler information, 511, Incident Responders, emergency management, table top exercise, hurricane evacuation signing, highway capacity, hurricane evacuation studies, ingenuity

South Dakota DOT Maintenance Decision Support System

Transportation agencies, which are responsible for providing safe, reliable highways throughout the winter season, face significant challenges:

- Travelers and commercial carriers with demanding delivery schedules expect higher levels of service.
- Transportation agencies have limited funding and staff.
- Reliable site- and time-specific reports of road conditions can be hard to get.
- Some weather conditions—particularly fog, frost, and blowing snow—can be difficult to forecast.
- Capabilities and limitations of new and innovative maintenance treatments are not fully understood.
- Agencies are losing their most seasoned maintenance workers, who have experienced diverse weather and treated a lot of roads during their careers.
- Transportation agencies face environmental challenges to the types and amounts of deicing materials they apply.

During the period of 2002–2012, the South Dakota Department of Transportation led a multi-state pooled fund study that developed and extensively deployed a Maintenance Decision Support System (MDSS). The work is directed by a Technical Panel representing every participating state and the Federal Highway Administration and is administered by the South Dakota Department of Transportation's Office of Research.

System Components: The premise behind MDSS is:

- if you know current road conditions;
- if you know the near- to medium-term weather forecast with confidence;
- if you understand and can model the chemistry and physics of road surfaces subjected to weather, traffic, and maintenance activities; and
- if you know available maintenance resources—equipment, materials, operators, and time;
- then MDSS can recommend sound winter maintenance strategies—treatments, application rates and timing—and predict the resulting road conditions. By analyzing available alternatives, MDSS recommends most cost-effective treatments.

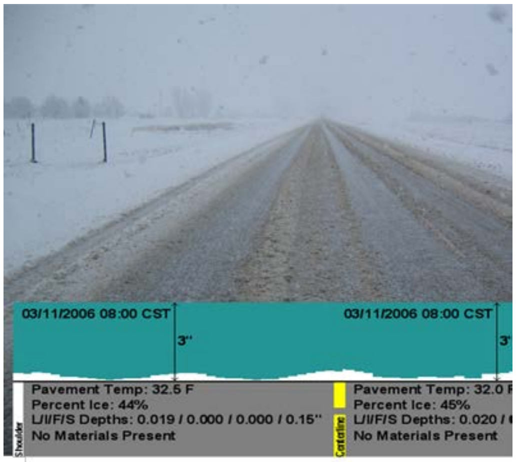

Figure SD-1. Surface conditions predicted by MDSS closely match actual road conditions.

Major MDSS components include:

- a vendor supplied and operated information system that assimilates a wide variety of weather and maintenance data and models pavement surface response to weather, already applied maintenance treatments, and feasible future treatments;

- a desktop graphical user interface customized to individual users, providing detailed information on weather and road surface conditions and predictions, as well as maintenance treatment recommendations;
- on-vehicle systems data systems that inform the MDSS of weather conditions, road conditions, and applied maintenance treatments and then inform equipment operators of predicted conditions and maintenance recommendations.

System Operations: The MDSS incorporates the scientific framework and computational tools necessary to reliably recommend sound winter maintenance treatment strategies:

- Report Current Road Surface Conditions—MDSS accepts observations of current road conditions from manual observations, on-truck instrumentation, and in-pavement sensors. If no observations are available, MDSS estimates the condition of the road surface on the basis of recent weather and reported maintenance.
- Report Actual Maintenance Treatments—Maintenance treatments (plowing and chemical application) are reported by manual entry or automatically by instrumented snowplows.
- Assess Past and Present Weather Conditions—MDSS not only considers current weather conditions—such as temperature, dew point, wind velocity and direction, precipitation type and rate, presence of blowing and drifting snow, cloud cover, and visibility—but also past conditions recent enough to affect the road surface.
- Assess Present Roadway State—MDSS's physical and chemical models of the pavement and the "active layer"—the mix of water, ice, chemical, and grit—predict temperature, moisture type and depth, and chemical concentration.
- Predict Storm Event Weather— MDSS uses sophisticated ensembles of computer models, supplemented with input from live meteorologists, to make site- and time-specific weather predictions for four to six hours short-term, and up to twenty-four to thirty hours long-term.
- Identify Feasible Maintenance Treatments—MDSS recognizes the specific constraints in equipment, materials, operating hours, and crew size that exist at each road segment, and only considers maintenance treatments that fall within those constraints.
- Target Agency Priorities—MDSS considers the agency's defined priorities regarding acceptable levels of service and the relative importance of a road segment compared to other segments.
- Predict Road Surface Behavior—Physical and chemical models in MDSS predict the future behavior of the active layer for each of the feasible maintenance treatments. For each treatment—chemical application, plowing, or a combination of both—the models predict whether the road will become dry, wet, snowy, or icy during the next several hours. MDSS can make predictions about numerous deicing materials, including liquids, brines, and salt mixtures.
- Communicate Recommendations to Supervisors and Workers—Finally, MDSS communicates treatment recommendations to truck operators or maintenance managers who direct fleet operations.

Transportation Outcome(s): Independent analysis of the benefits and costs of MDSS demonstrates potential for significant cost savings, improved service, or a combination of the two. A case study of New Hampshire's five previous winters showed that, had MDSS been used, 23% less salt could have provided the same level of service; alternatively, the incidence of "unacceptable" driving conditions could have been reduced by 10-15% with equal salt use. In either case, the overall benefit/cost ratio was about 8:1. Similar case studies in Minnesota and Colorado showed smaller, but worthwhile, benefit/cost ratios.

Indiana's statewide deployment of MDSS during the winter of 2008-2009 provides the most direct evidence of MDSS benefit. Using MDSS as a management tool, Indiana reduced salt costs by $12 million and realized more than $1M savings in fuel and overtime. Even after normalizing for winter conditions, Indiana estimated overall savings at $11 million, 27% of its normal total winter budget.

In addition to cost efficiency, MDSS users have realized other intangible but important benefits:

- "one-stop" convenience for complete winter weather information;
- better anticipation of storm events and resulting road conditions;
- delivery of weather forecasts and maintenance recommendations directly to snowplow operators;
- more consistent and seamless winter maintenance among maintenance units;
- reduced environmental exposure to deicing chemicals;
- use of the MDSS storm playback feature as a powerful maintenance training and analysis tool.

Implementation Issues: States in the MDSS Pooled Fund Study have achieved varying levels of deployment. Some states, especially those that joined the study early, have deployed extensively throughout their state highway systems. Others that joined the study more recently have established limited or pilot deployments. Deployment issues common to the states have included:

- adoption of new computer and communications technology
- user acceptance of a new winter maintenance paradigm
- developing technical expertise to support and use the technology effectively
- financial investments needed to deploy and operate the MDSS.

Contact(s):

- David L. Huft, Research Program Manager, 605-773-3358, dave.huft@state.sd.us

Reference(s):

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- Tony McClellan, P.E., Paul Boone, P.E., and Melody A. Coleman, 2009. *Indiana DOT Statewide Deployment Report.* <http://www.meridian-enviro.com/mdss/pfs/files/MDSSReportWinter08-09.pdf>
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Keywords: Winter Maintenance Decision Support

Tennessee DOT Low Visibility Warning System

In December of 1973, the segment of Interstate 75 near Calhoun, Tennessee, was opened to traffic. Following this date, multiple vehicle accidents occurred due to visibility problems experienced in foggy conditions. The culmination of these events occurred on December 11, 1990 when dense fog contributed to a series of chain-reaction collisions involving 99 vehicles with 42 injuries and 12 fatalities. In 1993, a fog detection and warning system was implemented along the Interstate section. This system includes a three-mile (five-kilometer) fog detection area spanning north and south of the Hiwassee River and an eight-mile (13-kilometer) warning zone on each approach to the fog prone area. In 2006, a project was initiated to upgrade the original system to current technology. Driver safety issues due to visibility problems have improved significantly since the system has been in place, with only one fog-contributed accident being recorded in 2001.

System Components: The fog detection component of the system is comprised of nine (9) forward-scatter visibility sensors (Figure TN-1), fourteen microwave radar vehicle detectors, and 21 Closed Caption Television (CCTV) cameras (Figure TN-2). Data from these devices is transmitted by buried fiber optic cable to an on-site control center. Information from the on-site control center is relayed to a central computer located in the Highway Patrol office in Tiftonia, Tennessee, with the use of a leased point-to-point, T1 communication link. In addition to the electronic instrumentation, reflective roadside delineators are placed in the detection zone at 80-foot increments for visibility estimation in the field.

Figure TN-1. Fog detector.

Figure TN-2. CCTV camera.

Figure TN-3. CSLS.

The fog warning component of the system is made up of six (6) static warning signs with flashing beacons, ten Changeable Speed Limit Signs (CSLS) (Figure TN-3), ten overhead Dynamic Message Signs (DMS), and two Highway Advisory Radio (HAR) transmitters. These warning systems are connected to the on-site control center by buried fiber optic cable, and to the central computer on the leased T1 communication link. In addition to the warning systems, six remotely operated swing gates are located at interchange on-ramps to control access to the interstate in the most severe conditions (Figure TN-4).

Figure TN-4. Swing gate.

System Operations: Operators monitor workstations connected to the system's central computer from the Tennessee Highway Patrol Office in Tiftonia, Tennessee. This computer system processes information from the detectors and alerts operators when pre-defined visibility or traffic speed thresholds have been reached. When these conditions are met, operators trigger pre-programmed messages to be displayed on the DMS boards, and notify the Highway Patrol troopers in the field. Troopers are stationed in the fog zone area daily during the fog prone hours (from 5 AM to 10 AM). After receiving word from the operators, troopers move to verify the roadway conditions by counting the number of reflective roadside delineators visible.

Table TN-1. Advisory and Control Strategies for Various Road Conditions.

<table>
<tr><th rowspan="2">Roadway Conditions</th><th colspan="3">Advisory & Control Strategies</th></tr>
<tr><th>OMS</th><th>CSLS</th><th>HAR</th></tr>
<tr><td>Case 1- Vehicle Speeds Below 45 mph</td><td>"CAUTION" alternating with "SLOW TRAFFIC AHEAD"</td><td>N/A</td><td>N/A</td></tr>
<tr><td>Case 2 - Fog Detected With Visibility Greater Than 1,320 feet (402.3 meters)</td><td>"CAUTION" alternating with "FOG AHEAD TURN ON LOW BEAMS"</td><td>"FOG" Displayed, & Flashing Warning Lights Activated</td><td>N/A</td></tr>
<tr><td rowspan="3">Case 3 - Fog Detected With Visibility Between 480 feet (146.3 meters) & 1,340 feet (402.3 meters)</td><td>"FOG AHEAD" alternating with "ADVISORY RADIO TUNE TO XXXX AM"</td><td rowspan="3">"FOG" Displayed, Speed Limit Reduced To *50 mph, & Flashing Warning Lights Activated</td><td rowspan="3">Activated</td></tr>
<tr><td>"FOG AHEAD" alternating with "REDUCE SPEED TURN ON LOW BEAMS"</td></tr>
<tr><td>"FOG" alternating with "SPEED LIMIT 50 MPH"</td></tr>
<tr><td rowspan="3">Case 4 - Fog Detected With Visibility Between 240 feet (73.2 meters) & 480 feet (146.3 meters)</td><td>"FOG AHEAD" alternating with "ADVISORY RADIO TUNE TO XXXX AM"</td><td rowspan="3">"FOG" Displayed, Speed Limit Reduced To *35 mph, & Flashing Warning Lights Activated</td><td rowspan="3">Activated</td></tr>
<tr><td>"FOG AHEAD" alternating with "REDUCE SPEED TURN ON LOW BEAMS"</td></tr>
<tr><td>"FOG" alternating with "SPEED LIMIT 35 MPH"</td></tr>
<tr><td rowspan="3">Case 5 - Fog Detected With Visibility Less than 240 feet (73.2 meters)</td><td>"DETOUR AHEAD" alternating with "REDUCE SPEED MERGE RIGHT"</td><td rowspan="3">"FOG" Displayed & Flashing Warning Lights Activated</td><td rowspan="3">Activated</td></tr>
<tr><td>"1-75 CLOSED" alternating with "DETOUR"</td></tr>
<tr><td>"FOG AHEAD" alternating with "ADVISORY RADIO TUNE TO XXXX AM"</td></tr>
</table>

***The initial posted interstate speed limit on the roadway section Is 70 mph.**

Currently, there are five separate cases in which fog warning and safety strategies are implemented. A decision is made as to what case is initiated based on the information provided by the system's control software and field observations. Table TN-1 details the five cases and the corresponding advisory and control strategies. In Cases 3 through 5, there are three separate messages for the DMS boards which appear relative to the sign's location from the incident. The messages displayed in these three cases are dependent on the relative location and scale of the fog event. The DMS board located on the peripheral of the system will display the first alternating message. When closure of the interstate section is warranted (Case 5), the ramp gates are closed and a detailed route detour scheme is coordinated by the Tennessee Highway Patrol. The local media is contacted for all levels of activation. A pre-recorded message is broadcasted from the HAR (Highway Advisory Radio) when activated by the operators. The control software allows for customized message to be displayed and broadcasted.

Transportation Outcome(s): From October 1st of 2011 to March 31th of 2012, the system detected fog in the target area a total of 45 times. This time frame represents the most active for fog production. Of the 45 times fog was detected by the sensors, advisory strategies were activated by the operators during 31 fog events. Of these events, 12 were elevated beyond the basic preliminary warning to a speed reduction. Since the system became operational, visibility conditions have warranted closure of the interstate section on two occasions: once for fog, and once for the presence of toxic smoke from a chemical plant fire.

Driver safety issues due to visibility problems have improved significantly since the system has been in place, with only one fog-contributed accident being recorded, in 2001. There were no fatalities from this accident. The fog warning and detection system has the additional benefit of providing an effective tool for general incident management. In the October 2011 to March 2012 time period, the system was manually activated to alert motorists of non-fog related incidents 34 times.

Implementation Issues: In the years leading up to the 1990 multi-vehicle incident, the Tennessee DOT and THP had implemented methodologies to help prevent fog-related accidents. In 1980, the DOT completed improvements that included enhanced striping, adding raised pavement markers, adding flashing beacon warning signs, and providing portable detour signs for the THP. The 1990 accident spurred increased research, and the development of an interdepartmental plan of action. The existence of waste treatment facilities from a nearby paper plant necessitated studies into both the natural and man-made causes of fog production. After a review of available technology, it was decided that a fog detection and warning system should be implemented to augment safety practices carried out by the Tennessee Highway Patrol.

The planning and design process of the system was aided by a review of a low visibility warning system located in Charleston, South Carolina. With defined requirements for the system functionality, the overall project area (based on fog incident information), and field component locations were selected. System redundancy was built-in to provide backup communication and power capabilities. The fog detection and warning system became operational in December of 1993.

In 2005, a determination was made that a renovation of the fog system was required. The various components that made up the system had aged to a point where it was difficult to continue operations and maintenance. A systems-engineering approach was used to ensure compatibility with future technologies and additions. Included in this upgrade was the integration of a CCTV video component. These cameras, mounted on 50-foot poles throughout the fog zone, are used to verify system operation and monitor weather and traffic conditions.

The incorporation of the CCTV video required an improvement in the system's communication abilities. The original system transmitted data with the use of a wireless radio microwave link. The required bandwidth for full-motion, real-time video and responsive remote camera operation made the wireless system a less desirable design. The updated fog system operates with a leased, point-to-point, T1 communication link. In the future this T1 link will be replaced by a department-owned fiber optic link from the on-site control center to the Traffic Management Center (TMC) in Chattanooga, Tennessee.

Contact(s):

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- Lt. Tommie Graham, Tennessee Department of Safety, 423-634-6898, Tommie.Graham@tn.gov

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Keywords: fog, visibility, low visibility warning system, freeway management, traffic management, emergency management, law enforcement, advisory strategy, motorist warning system, traveler information, control strategy, speed management, access control, decision support, vehicle detection, environmental sensor station (ESS), variable speed limit (VSL), closed-circuit television (CCTV) cameras, dynamic message signs (DMS), highway advisory radio (HAR), gates, crashes, safety, Traffic Management Center (TMC)

Texas DOT High Water Detection System

High water detection systems (HDWS) are installed in stream beds at road and stream crossing locations with a potential or a history of flooding. The Texas Department of Transportation (TxDOT) has installed twenty such of these systems throughout the San Antonio area. An additional six are being installed in 2012. The San Antonio district has installed one system in the metro area, while the other units (including the six new units under construction) have been installed in the rural areas surrounding San Antonio, primarily at locations in the Texas Hill Country, which are subject to flash flooding due to the region's topography. The first units were installed in 2005. The unit cost is typically $75,000.

System Components: The HWDS consists of the following elements:

- A stand pipe installed in the stream bed or measuring device attached to the crossing structure (bridge or culvert)
- Wire line or wireless communications from the measuring system to the local computer
- Wire line or wireless communications from the local computer to advanced warning signs
- Advanced warning signs, with flashers
- Central/Master software
- Cellular communications from the systems to a contracted operations center
- Internet-based communications from the contracted operations center to TxDOT's network
-

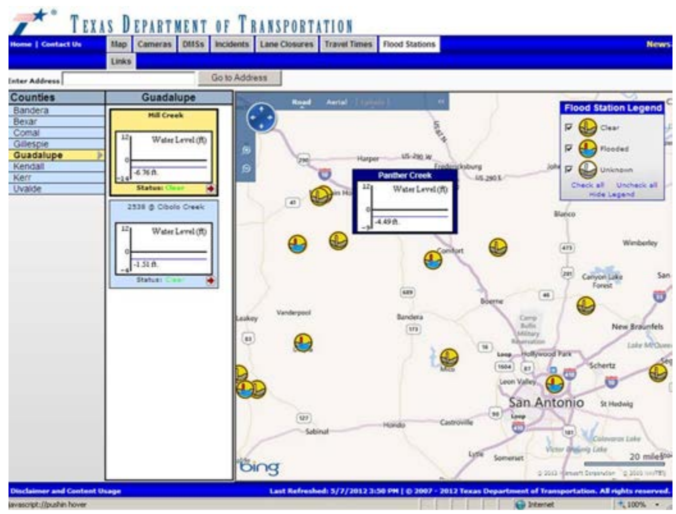

Figure TX-1. Public Internet display of TxDOT-San Antonio high water detection systems.

System Operations: The level of water in the stream bed is measured by a stand pipe or a device mounted on the bridge or culvert crossing the stream. The water level is transmitted to a local computer mounted in a cabinet near the stream crossing (which is installed above the flood elevation). The local computer activates flashers on warning signs on the approaches to the stream crossing. The local computer also transmits system status and water elevation to the central software application at the contracted operations center. Local topography for each location determined during installation and the water elevation data provided by the local computer are used to create a public Internet display, as seen in Figure TX-1, which provides a graphic display of the conditions. The conditions are noted as flooded or not flooded, or no data available. A secure web site is available for TxDOT staff that provides detailed information regarding each system's status, operational history and historic water levels.

-

Transportation Outcome(s): The San Antonio HWDS allow emergency responders, TransGuide Operators, TxDOT public information, the public and the media to monitor the conditions at the locations during a rain event. The flasher equipped advanced warning signs provide a notification to drivers that a road is flooded ahead. It allows maintenance crews to monitor the HWDS from their offices and dispatch crews to set barricades when flood conditions are imminent.

Implementation Issues: The majority of TxDOT's locations are in remote areas. Establishing communications to those sites required working with cellular providers, and identifying the best location for the equipment cabinet based on the topography and wireless coverage availability. All current TxDOT HWDS were installed by one manufacturer. The six new units are being installed by a second manufacturer. To ensure the data from the HWDS from any manufacturer is available, TxDOT required that the manufacturers provide the data using a specific protocol found in TxDOT's Environmental Sensor Station documentation. That protocol is compliant with the National Transportation Communications for ITS Protocol (NTCIP).

Contact(s):

- Brian G. Fariello, P.E., Traffic Management Engineer, TxDOT-TransGuide, 210-731 5247, brian.fariello@txdot.gov

Reference(s):

- Texas DOT – San Antonio District Flood Station Map and Information webpage <http://www.transguide.dot.state.tx.us/ITS_WEB/Frontend/default.html?r=SAT&p=San%20Antonio&t=ess>

Keywords: TxDOT, TransGuide, Storm, Water, Detection, Pump, Flood, Stream

Texas DOT Pump Station Monitoring System

The San Antonio District of the Texas Department of Transportation (TxDOT) installed monitoring systems in six storm water pump stations in locations where the roadway is below natural ground level. The pump stations are used to lift storm water to an elevation where the outflow can enter the gravity flow storm drainage system. The Monitoring Systems are used to determine the status of the pumps, determine the level of water in the wet wells, and provide an approximate time until the location floods. Before the monitoring systems were installed, maintenance crews had to visit each pump location during rain events to ascertain the status of the pumping equipment. The monitoring systems allow the maintenance crews to visit only the sites where maintenance issues and/or flood conditions require. The units were originally installed in 2000, but were recently upgraded at a cost of $13,000 each.

System Components: The Pump Station Monitoring system consists of equipment located in the pump stations, communications to the TransGuide Operations Center, and an Internet display of the pump station data for TxDOT maintenance and operations staff. The equipment in the system includes the following elements:

- Field Computer
- Remote terminal unit
- Analog Input Module
- Pump Station Uninterruptible Power Supply (UPS)
- Internet Protocol (IP) Network Interface
- Central/Master Software
- Internet display

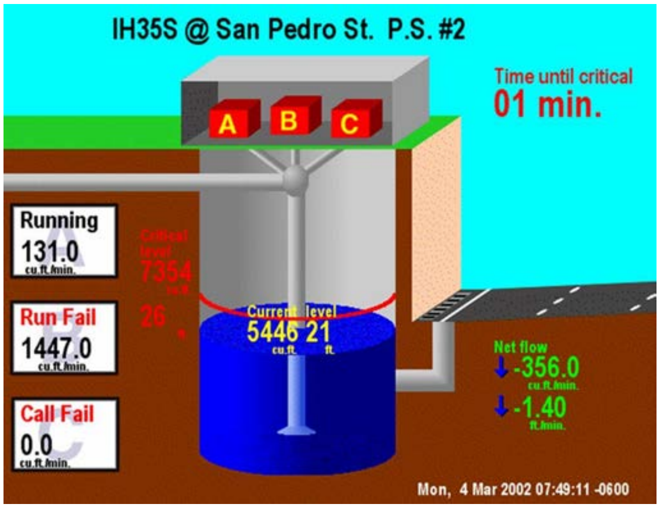

Figure TX-2. Storm water pump station: graphic image available to TxDOT operations and maintenance staff.

System Operations: The Pump Station Remote Terminal Units (PRTU) are connected to the sonic detector installed at the top of the wet well, which is used to determine the level of the water in the wet well. The sonic detector is connected to the pumps, and activates the pumps based on the water level. The PRTUs are connected to the pumps using contact closures, and determine when the pumps are in operation. The PRTUs transmit data from the pump stations to the TransGuide Operations Center. The pump station data is processed by the central software, and is available to TxDOT operations and maintenance staff using a non-public Internet display. The maintenance staff operations staff can dispatch technicians to repair failed pumps, or dispatch crews to set barricades if flooding of the roadway is imminent. Operations staff can place warning messages on Dynamic Message Signs, notify TxDOT public information staff and the media of flood conditions, and notify emergency services when flood conditions are present.

Transportation Outcome(s): The San Antonio pump stations monitoring systems allow TransGuide operators to monitor pump operations during a storm incident and inform the public and response agencies should the pumps not be able to keep up with demand. It allows maintenance crews to monitor the pump stations equipment, dispatch repair technicians, and dispatch crews to set barricades when flood conditions are imminent.

Implementation Issues: Implementation of the pump station monitoring systems required that equipment from several manufacturers be interconnected. TxDOT was not aware of any prior applications where this equipment was used in this manner. The sonic detector had a standard data output port which was used as the basis of the system. Using the data output port, the detector provided the elevation of the water in the wet well. A remote terminal unit was identified that allowed for multiple contact closure connections (required for the pump status), in addition to receiving the elevation data from the sonic sensor. A software application was developed that included the central software and the software required for the computer in the remote terminal unit. The physical characteristics of the pump stations varied (engines, wet well diameter & height), and had to be researched for each pump station. The elevation of water in the wet well that would result in flooding of the roadway was initially estimated, and updated based on observed conditions following activation of the systems.

Contact(s):

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Reference(s):

- Texas DOT – San Antonio District Flood Station Map and Information webpage <http://www.transguide.dot.state.tx.us/ITS_WEB/Frontend/default.html?r=SAT&p=San%20Antonio&t=ess>

Keywords: TxDOT, TransGuide, Storm, Water, Pump, Station, Detection

Utah DOT Traveler Information Weather

The Utah Department of Transportation (UDOT) endeavors to provide timely, accurate and consistent weather-related traveler information so that travelers can make informed travel decisions. In response to this mission, UDOT has started the Traveler Information (TI) Weather program to provide the public with high quality road-specific forecasts before weather events, and timely road condition observations during and after events. Through human-powered forecasting, condition reporting and partnering with other agencies, this program equips travelers with road weather information, helping them to make safe travel choices.

System Components: The TI Weather program consists of three contracted meteorologists located in UDOT's Traffic Operations Center (TOC). TI meteorologists distribute working hours among themselves to fully cover hazardous weather events. They work alongside the TOC's maintenance and operations weather forecasters (who are also contractors), but serve public motorists specifically. There are two products they provide to the public:

- Road weather impact forecasts
- Road condition reports

These products are available on the UDOT Traffic website, smartphone app, Twitter account, and on the 511 phone line.

TI meteorologists also provide customer service to public motorists with travel weather questions. Other duties include assisting with internal weather briefings for traffic operations personnel and compiling road weather data from each storm for post-event reviews. The program is joint-managed by the Weather Operations Manager and Traveler Information Manager.

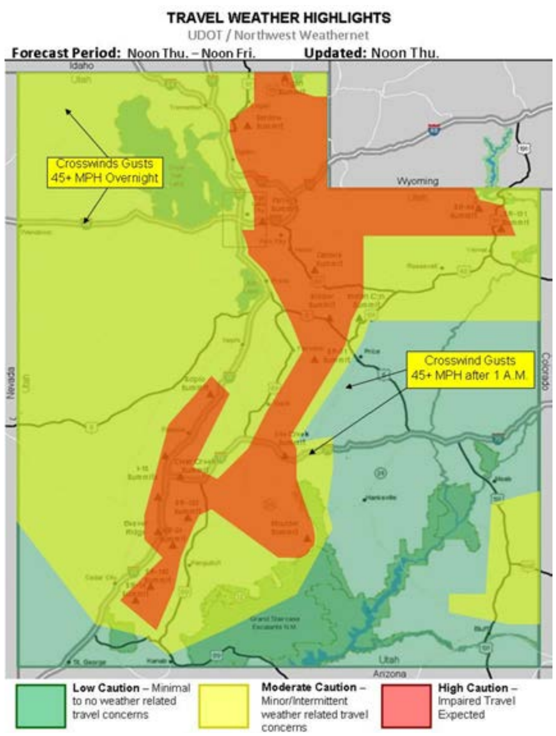

Figure UT-1. Weather impact graphic from March 1, 2012.

System Operations: Road weather forecasts focus on expected travel impact resulting from upcoming weather. An example forecast graphic is shown here in Figure UT-1. These graphics accompany text forecasts and are posted as a Road Weather Alert on the UDOT Traffic website and app. Each segment of Utah's state highways receives a manually-composed forecast, which provides details pertinent to travelers. The TI Meteorologists also record 511 messages which explain upcoming impacts in a way travelers can understand.

An important and unique aspect of pre-storm messaging is collaboration with the local National Weather Service (NWS) forecast office located in Salt Lake City. Forecasters from both agencies ensure the message is consistent between both agencies' advisory products so that the public is not receiving conflicting forecasts from multiple agencies. NWS products are more visible by media and public, and in this way, the message of travel impacts can reach a much larger audience than UDOT may be able to on its own.

Road condition reports are updated hourly from the TOC and at least twice daily from plow operators in the field. Plow operator reports are favored for their on-the-ground accuracy, but they lack the timeliness the public demands. Plow operations requires a high level of focus on safety and snow/ice mitigation, especially during hazardous and changing conditions, and reporting conditions becomes a lower priority. Utilizing in-field sensors, cameras, radar, forecasting models and direct communication with field personnel, the TI meteorologist populates these reports at a high frequency for UDOT's TI outlets. UDOT also plans to initiate a citizen reporting program in the near future.

Transportation Outcome(s): The TI Weather program has improved UDOT's level of service for public information. It has contributed to increased road weather awareness among media and public in Utah as they begin to understand the difference between "sensible" weather and road weather. For example, three inches of snow forecast to accumulate on grassy terrain may or may not translate to travel impacts, depending on road temperature, precipitation intensity, mitigation strategies, and so forth. It is assumed a road weather-savvy public will make more informed travel decisions before, during and after storms. Safer travel and increased road capacity during storms is an anticipated outcome.

Communications technology has greatly increased the ability for information to be disseminated to the public in real-time, and as a result, UDOT's road condition reports are more visible than prior technology would have enabled. Hourly updates satisfy a public need for this important safety information.

At less than $140,000 per year, the cost of providing this service is relatively minimal for the important public service. UDOT has found that human-powered forecasts and road condition reports are produced at a much lower cost than running certain types of road weather models or relying strictly on automated field devices. Despite the low program cost, the forecasts are proven to be highly accurate, enabled in large part by human interaction in the forecast and observation processes. The TI meteorologists are removing some burden from the maintenance forecasters, who have been historically been limited to providing only a small component of public weather needs. This program has been very well received and supported in UDOT.

Implementation Issues: Basic software development was required to support the system. Local meteorologists with Bachelor's degrees were recruited for the positions.

Contact(s):

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- Lisa Miller, Utah DOT Traffic Management Division, Traveler Information Manager/PIO, 801-887-3761, lisamiller@utah.gov

Reference(s):

- TI Weather products available at <udottraffic.utah.gov/RoadWeatherForecast.aspx>
- Jones, L., G. Merrill, K. Barjenbruch, R. Graham, "Innovations in Impact-Based Wintertime Road Weather Warnings in Utah," 1st Conference on Weather Warnings and

Communication, Oklahoma City, June 2011, available at <http://ams.confex.com/ams/39BROADCAST/webprogram/Paper189115.html>

Keywords: traveler information, road weather, RWIS, forecast, 511, website, smartphone app

Vermont Agency of Transportation: Transportation Operations Center

The Vermont Agency of Transportation (VTrans) Transportation Operations Center (TOC) is the focal point for VTrans' Intelligent Transportation Systems (ITS) road weather management and traveler information systems operations. TOC staff are responsible for monitoring various ITS devices statewide, communicating with VTrans' road crews, public safety (state and local), and emergency providers via radio and telephone, and updating the general and traveling public via Condition Acquisition Reporting System (CARS). TOC staff input information into CARS and CARS disseminates the information out to the public via 511, Variable Message Signs (VMS), Low Power Frequency Modulation (LPFM) stations, web, e-mail, and text notifications.

Figure VT-1. Traffic operations center.

System Components: The TOC consists of:

- Two Communications Specialists
- Internet Protocol (IP)-based Radio System that connects to all nine VTrans' districts as well Vermont State Police Dispatch and local police.
- Video Wall for displaying data and video feeds from RWIS, local news, as well as different websites including 511.

Figure VT-2. Traffic operations center's Gregory Fox, VTrans' communications specialist.

System Operations: The TOC relies on various ITS devices such as RWIS, VMS, 511, and LPFM (Low-Power FM).

The TOC has improved VTrans traveler information dissemination as well as winter road maintenance by providing VTrans' maintenance crews with advanced weather information to allow crews to be proactive versus reactive to road and weather conditions throughout the state. This advanced weather information is ascertained by TOC crews monitoring National Oceanographic and Atmospheric Administration (NOAA), National Weather Service (NWS), as well as local radar to see what types of weather patterns are heading toward Vermont. In addition they provide RWIS data to Lyndon State College Meteorology Department (LSC). LSC takes the data and inputs it into their computer models to analyze the data and provide accurate forecasts to the VTrans districts and 24 to 48 hour advanced weather forecasts.

Figure VT-3. Traffic operations center Mark Gerrish, VTrans' fiber optic project manager.

Transportation Outcome(s): The TOC, though small and undermanned, has provided a wealth of information to VTrans' maintenance crews and the travelling public regarding adverse driving conditions during the winter, lane and road closures during road construction projects, and road closures due to crashes. VTrans' maintenance crews heavily rely on feedback from TOC staff as they monitor RWIS data and camera images, NOAA, NWS, and local weather radar, etc. This gives the maintenance crews more time to plan on winter maintenance activities versus waiting for the event to happen and then having to react. Crews can have trucks loaded with correct materials (salt, sand, de-icing, etc.) and in some cases pre-treat roads before winter events occur. The immediate benefit is less material wasted along with man-hours for having to return to the garage to change out materials due to changes in the weather patterns.

The travelling public and local media (TV and radio) have come to rely on 511 (both phone and web) and the various information disseminated. VTrans receives constant feedback (both positive and negative) from the public on how well the systems are working and how the information is used to make their travel more pleasant and feasible.

Implementation Issues: As with all new technology, implementation issues that have affected the TOC the most are reliability issues with ITS devices. VTrans relies heavily on the technology vendors to maintain and troubleshoot problems with the ITS devices. When an ITS device goes down, it may take the vendor a week or more to troubleshoot and fix. While the device is down, TOC staff cannot receive or review data from the device. This creates holes in the TOC staff's ability to provide information to road crews and the travelling public.

As stated earlier, VTrans TOC is undermanned making it nearly impossible to provide up to date information at all times. To offset this, VTrans has looked at automating some features including allowing RWIS to control VMS in their vicinity and display pertinent messages related to the adverse weather conditions detected by the stations. However in order to do this, the RWIS and VMS must be reliable, i.e., on and in proper working condition.

Another factor is communications. Because Vermont is such a rural state, Vermont is lacking in telecommunications infrastructure. This has also made it hard to implement ITS devices statewide and has thus further restricted the TOC's "eyes and ears" as to what is happening (weather and road incidents) around the state.

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- Robert T. White VTrans ConnectVermont ITS Administrator, 802-828-2781, Robert.T.White@state.vt.us
- Alec Portalupi VTrans Maintenance Engineer, 802-828-3889, Alec.Portalupi@state.vt.us

Reference(s):

- State of Vermont 511 website <http://www.511vt.com>
- Vermont Agency of Transportation website <http://www.aot.state.vt.us/>
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Keywords: Traffic Operations Center, road weather information systems

Acronym List

AFWS	Automated Flood Warning System
AASHTO	American Association of State Highway and Transportation Officials
ATIS	Advanced Traveler Information System
ATS	Automated Transportation System
ATM	Active Traffic Management
ATMS	Advanced Traffic Management System
AVCS	Advanced Vehicle Control System
AVL	Automatic Vehicle Location
AWOS	Automated Weather Observation Systems
B/C	Benefit/Cost
BMP	Best Management Practice
CARS	Condition Acquisition Reporting System
CCTV	Closed Circuit Television
CDPD	Cellular Digital Packet Data
CHP	California Highway Patrol
CMAQ	Congestion Mitigation and Air Quality
CMS	Changeable Message Signs
CSLS	Changeable Speed Limit Signs
DCP	Data Collection Platform
DCS	Data Collection System
DMS	Dynamic Message Sign
DOT	Department of Transportation
DPS	Department of Public Safety
DSL	Digital Subscriber Line
DSS	Decision Support System
DUST	Dual Use Safety Technology
EMS	Extinguishable Message Signs
EOC	Emergency Operations Center
ESS	Environmental Sensor Station
EVMS	Equipment Vehicle Management System
FDWS	Fog Detection and Warning System
FIRST	Freeway Incident Response Safety Team
FHWA	Federal Highway Administration
FMS	Freeway Management System
GIS	Geographic Information System

GOES	Geostationary Operational Environmental Satellite
GPS	Global Positioning System
HAR	Highway Advisory Radio
HARS	Highway Advisory Radio Service
HAZMAT	Hazardous Material
HDWS	High Water Detection Systems
HOT	High Occupancy Toll
HOV	High Occupancy Vehicle
IAP	Incident Action Plan
ICS	Incident Command System
ICWS	Icy Curve Warning System
ILCS	Intelligent Lane Control Signals
IP	Internet Protocol
IRIS	Intelligent Roadway Information System
ISP	Information Service Provider
ITS	Intelligent Transportation System
KHP	Kansas Highway Patrol
KTA	Kansas Turnpike Authority
LED	Light Emitting Diode
LPFM	Low Power Frequency Modulation
LSC	Lyndon State College
MDC	Mobile Data Collection
MDSS	Maintenance Decision Support System
MMDI	Metropolitan Model Deployment Initiative
MMS	Maintenance Management System
MRC	Measurement Research Corporation
MS/CVE	Measurement Standards and Commercial Vehicle Enforcement
MVDS	Microwave Vehicle Detection System
NCHRP	National Cooperative Highway Research Program
NDFD	National Digital Forecast Database
NOAA	National Oceanographic and Atmospheric Administration
NTCIP	National Transportation Communications for ITS Protocol
NWS	National Weather Service
OFCM	Office of the Federal Coordinator for Meteorology
OK-FIRST	Oklahoma's First-response Information Resource System using Telecommunications
OLETS	Oklahoma Law Enforcement Telecommunications System

PC	Personal Computer
PLC	Programmable Logic Controllers
PMR	Performance Measurement and Reporting
PTR	Pointer Record
PRTU	Pump Station Remote Terminal Unit
PVC	Polyvinyl Chloride
RPU	Remote Processing Unit
RTMC	Regional Traffic Management Center
RVD	Radar Vehicle Detection
RWIS	Road Weather Information System
SCADA	Supervisory Control and Data Acquisition
SCHP	South Carolina Highway Patrol
SEOC	State Emergency Operations Center
SHA	State Highway Administration
SHEP	State Highway Emergency Patrol
STC	Smart Traffic Center
STMC	State Traffic Management Center
TCC	Traffic Control Center
TDP	Temperature Data Probe
THP	Tennessee Highway Patrol
TI	Traveler Information
TMC	Traffic Management Center
TP	Tow Plow
TOC	Traffic Operations Center
TRIS	Transportation Research Information Services
TTX	Table Top Exercises
UHF	Ultra-High Frequency
UPS	Uninterruptible Power Supply
US	United States
USDOT	United States Department of Transportation
UTCS	Uniform Traffic Control System
VDS	Vehicle Detection Station
VHF	Very High Frequency
VMS	Variable Message Sign
VSL	Variable Speed Limit
VSS	Variable Speed Sign
WAN	Wide Area Network

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