Second National Stakeholder Meeting on Weather Responsive Traffic Management (WRTM)

Meeting Summary Report
September 25-26, 2013
Salt Lake City, Utah
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Introduction

The second Stakeholder meeting and workshop on Weather Responsive Traffic Management (WRTM) was held on September 25-26, 2013 in Salt Lake City, Utah. Over a day and a half, invited participants discussed the state of the practice and future direction to better manage traffic during adverse weather. Appendix A includes the meeting agenda. The participants included representatives from 26 State DOTs, private contractors and the federal government. Figure 1 shows the geographic distribution of the State DOT representatives, and Appendix B includes the list of all attendees in the meeting.

![Figure 1. Represented States at the Second WRTM Meeting](image)

This report summarizes the discussions and identifies the resulting action items from the meeting. The report is organized as follows:

- Section 2 describes the WRTM program and the meeting objectives.
- Section 3 identifies the key messages heard during the discussions.
- Section 4 provides the session-by-session summary.
- Section 5 lists the action items identified from the meeting.
- Section 6 summarizes the feedback given by the participants about the meeting.
1.0 Meeting Objectives and Desired Outcomes

Given the WRTM state of the practice and research activities, the meeting was intended to achieve the following objectives:

- Provide updates on successful implementations of WRTM by transportation agencies.
- Disseminate research results, available tools, and training opportunities.
- Identify emerging technologies and trends to support WRTM including Connected Vehicles.
- Identify gaps, challenges, and opportunities in implementing WRTM strategies.
- Determine future research, development, and deployment areas for the Federal Highway Administration (FHWA) WRTM program.

At the end of the meeting, the participants were expected to be:

- Informed about new developments in WRTM including recent research, implementations and evaluations.
- Aware of available tools and resources to guide and support their WRTM implementation.
- Aware of benefits of WRTM and continue to serve as champions for WRTM adoption in their agencies.

The general feedback from the participants was very positive as shown in Table 1.

2.0 Key Messages from the Meeting

The following represent some high-level themes that were heard at multiple sessions during the meeting.

**Theme 1 – Collaboration and integration will help advance the state of practice for WRTM:** WRTM is a multi-agency effort with players both inside and outside the transportation agency. Participants noted that there are significant benefits in collaborating both within the agency (operations and maintenance) and outside with private sector data partners, emergency responders and operations, and the media. We need to continue to work together and strive for more collaboration and integration – not just from a staff level but also with data. In addition, the National Weather Service (NWS) and other agencies within the National Oceanic and Atmospheric Administration (NOAA) need to be included to help them understand the impacts of their data on road weather conditions and DOT actions.
Theme 2 – Educate and manage expectations of travelers during weather: Participants noted that traveler expectations of road conditions need to be managed continuously. Setting expectations on the timeliness, content, and method(s) of communication for information is important. This helps to establish a foundation of trust, reliability, and accessibility.

Theme 3 – Social media matters: Related to theme 2, participants noted a growing expectation from their travelers for information through social media. Social media requires a commitment by agencies to ensure information is posted in a timely manner and the ability for agencies to be creative and have a little fun with how they interact with their drivers. An effective social media campaign can allow an agency to take control of their image.

Theme 4 – Measure WRTM performance: WRTM often has to compete against other priorities at the State DOT. How we measure the performance of individual strategies is an ongoing question. What evaluation tools/frameworks are best suited for WRTM type applications? Participants also noted that creation of traveler surveys related to weather can help with assessing traveler behavior. It should be noted that evaluation guidance is provided in the FHWA report “Developments in the Weather Responsive Traffic Management Strategies”.

Theme 5 – Innovation: For many agencies there is a desire to advance but limited resources to do so. Innovative strategies such as citizen reporting programs and active traffic management strategies (such as variable speed limits and weather-responsive ramp metering) can provide opportunities for improved traveler information and travel flow without major capital investment.

Theme 6 – We’re making progress – but there are still areas that require more attention: In recent years, there has been a lot of research focused on the impact of rain and snow – but there is a need to increase the discussion to include flooding and hydrology. Water is a powerful force that can take out a roadway and we need to better understand flooding impacts on the transportation system. Another key element that requires more attention is fog. Reduced visibility due to fog can be influenced due to multiple reasons. Understanding how this affects the roadways is vital information.

Theme 7 – Share technical knowledge and success stories among the stakeholder community: Participants noted that it was through forums like this that allowed them to interact with their peers to share WRTM experiences. They indicated a need to share technical knowledge and success stories among the community.
3.0 Session Summaries
The following sub-sections provide summaries of discussion during each of the sessions of the meeting. The speakers and the agenda are included in Appendix A.

3.1 Opening Session and WRTM Overview
This session included welcoming remarks to the participants from Mark Kehrli, Director of the FHWA Office of Transportation Operations and Shane Marshall, Deputy Director of Utah Department of Transportation (UDOT). In addition, Roemer Alfelor provided an update on the WRTM Program at FHWA.

3.1.1 WRTM Opening Session (Mark Kehrli – FHWA and Shane Marshall- UDOT):
Mark Kehrli has been the Director of the FHWA Office of Transportation Operations since January 2010. Prior to this appointment, Mark served as the Division Administrator in the District of Columbia (DC), a position that he held since 2006.

FHWA has developed a strategic plan with four corporate goals:
- National Leadership, which focuses on what the agency is doing to advance something new/advance the state of practice (Recovery Act, Performance Measures – MAP-21)
- Program Delivery, which focuses on the agency’s large Federal Program and its delivery through the States and role of FHWA Division Offices
- Corporate Capacity, which looks at what we are doing as an agency to ensure that the necessary resources are in place to carry out the mission.
- System Performance, which includes looking at road/bridge/pavement conditions as well as climate and sustainability factors. They key here is how we are operating the system.

FHWA has also been investing in the Strategic Highway Research Program (SHRP) 2. Research under the SHRP 2 program focuses on reducing congestion through incident reduction, management response, and mitigation. More information on the SHRP 2 program can be found at: http://www.trb.org/StrategicHighwayResearchProgram2SHRP2/Public/Blank2.aspx

Shane Marshall was appointed Deputy Director of the Utah Department of Transportation (UDOT) in June 2013. He joined UDOT in May 1995. Shane has served in several other UDOT positions, including Region Three Director, Region Three Program Manager, and Director of Environmental Services.

Utah has a diverse climate and geography from flash floods to snow storms. UDOT started its weather responsive traffic management program during the Salt Lake City Olympics in 2002 and it has really grown since then – and been bought into by stakeholders. Since the initiation of the program it has been able to implement a lot of efficiencies, which has helped with the continued success and innovation – including areas such as snow removal and process development. UDOT’s goals for the weather program include:
- Preserving infrastructure through improved weather forecasting and implementation of efficiencies in our response plans.
- Optimizing mobility through advanced warnings of weather changes with the goal to change traveler behavior and reduction of gridlock.
- Zero fatalities by providing knowledge to travelers to help reduce the number of people on roads.
• Strengthening the economy by implementing the above three goals.

UDOT currently has one full-time forecaster and five consultants supporting its program with shifts fluctuating during winter months to allow for increased support. UDOT began pushing more weather-related information out to the public in 2009 and has utilized a number of different mechanisms to do this – 511, Twitter, and mobile apps are all part of our approach. Looking ahead, UDOT is always trying to identify opportunities for increased efficiency through new processes and procedures. UDOT will be working on a road weather index to help prioritize plowing. It has a finite number of plows so depending on where the snow hits and how much – it can optimize the use of their resources. UDOT has found that the public, in general, doesn’t care about how much snow – they just want it gone. UDOT needs to be able to communicate about what it is able to do.

3.1.2 WRTM Program Overview (Roemer Alfelor – FHWA):
The impact of weather on congestion and fatalities is significant. There are over 1.5 million weather-related crashes per year, with 7,130 fatalities per year, and over 629,000 injuries per year.

• 24% of all crashes occurred on slick pavement or under adverse weather.
• 15% of total delays and 25% of non-recurring delays are weather-related.

Weather Responsive Traffic Management Program Goals include:
• Help transportation agencies use current and forecast weather and traffic conditions to manage traffic flow and highway operations.
• Help motorists receive and respond to road weather and traffic information.
• Incorporate weather impacts in traffic analysis and engineering models.
• Improve traffic safety and mobility during adverse weather.

Figure 2 shows the WRTM Framework. WRTM strategies fall into three categories: advisory; control; and treatment. Advisory strategies include warming systems and traveler information systems. Control strategies include signal timing, ramp metering, variable speed limit, and road/lane closures in response to weather conditions. Treatment strategies include maintenance and obstruction removal.
Current program activities include:

- WRTM Webinar Series (Feb, March, May, Nov)
- Guidelines for Disseminating Road Weather Messages
- Guidelines for Variable Speed Limit (VSL) Implementation during Wet Weather
- WRTM Web-based Training (CITE)
- Weather Responsive Traffic Estimation and Prediction System
- Advanced WRTM Strategies Implementation
  - Traveler Information System (Utah DOT)
  - Active Traffic Management (Oregon DOT)
  - Traffic Signal Control (Utah DOT)

Future program activities include:

- Using Mobile Data for WRTM Strategies (Michigan, Wyoming, and South Dakota)
- Cost/Benefit Analysis of WRTM Strategies
- Continuation of the WRTM Webinar Series
- Analysis, Modeling and Simulation Test Beds for RW Connected Vehicle Applications
- 3rd National WRTM Meeting (Sept. 2015)

More information about the WRTM program is available from:

### 3.2 A Tough Year: Real-World Experiences and Applications of WRTM

This session provided examples from three agencies on their recent application of WRTM strategies during adverse weather, and highlighted lessons learned and challenges.

#### 3.2.1 Winter Storms in Mid-West – Kansas City (Nancy Powell – KC Scout TMC):

The Kansas City Scout (KC Scout) Weather Integration Project was launched in 2009 as part of a pilot program with FHWA. The KC Scout team developed an implementation plan, which then led to deployment of 6 integration strategies in 2011 as shown in Table 2:

<table>
<thead>
<tr>
<th>Category</th>
<th>Strategy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Advisory</td>
<td>Disseminate weather information to broader audience</td>
</tr>
<tr>
<td></td>
<td>Provide better en-route weather information to the public</td>
</tr>
<tr>
<td>Institutional Coordination</td>
<td>Develop and implement weather event policies</td>
</tr>
<tr>
<td>Treatment Operations</td>
<td>Improve timeliness of weather event response</td>
</tr>
<tr>
<td>Weather Information Processing and Gathering</td>
<td>Adjust operations based on weather information</td>
</tr>
<tr>
<td></td>
<td>Provide real-time weather alerts and updates</td>
</tr>
</tbody>
</table>

The new system was not fully tested until February 2013 due to a mild winter in 2012. The Team has integrated National Weather Service (NWS) advisories into their advanced traffic management system.

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(ATMS) and widely publicized advance notice of the storm that hit in February 2013. They posted messages on their DMS about the storm watch and storm warning and also posted messages that travel was not advised and abandoned vehicles would be towed.

The February 2013 storm event had 110 incidents; of which 96 were winter storm related. Approximately 70 of the 96 weather related events occurred on an interstate. All combined the incidents resulted in 98.5 hours of impacted roadways. The Team utilized social media to educate the public about the impending storm and road conditions. They also have a media room that is adjacent to their Traffic Management Center (TMC), which enables quick coordination with the media. The team learned some valuable lessons from their weather event:

- Successes included 24/7 media access to TMC activity; positive public response; and timely incident notification and updates.
- Failures included not having enough capacity for towed vehicles and a plan in place for how to organize towed vehicles for owner retrieval (a plan has since been developed); not having planned for accommodating staff due to road conditions; and having less experienced snow plow drivers due to previous job cuts.

3.2.2 Flooding from Hurricane Sandy - New Jersey (Jim Hadden – NJ DOT)

Based on lessons learned from prior events and awareness that this storm was going to have a significant impact on the state and region, NJDOT took proactive measures pre-hurricane to ensure they were prepared to provide assistance. Pre-hurricane operations and ITS strategies included:

- Fueled up all Safety Service Patrol trucks as well as NJDOT Incident Management Response Team vehicles.
- Installed snow plows on all vehicles.
- Performed system checks on all ITS field devices noting devices that are currently under repair or not working.
- Prepared standard VMS Messages for all roadway agencies.
- Prepared consistent floodgate messages for 511.
- Created a separate 511 web page for “out of the box” information that is not part of the automated traveler information.
- Reviewed Contra Flow plans for all evacuation routes.
- Increased staffing levels at the operations center as well as the three regional operations centers.
- Ensured that there would be 24/7 coverage for the potential of ITS asset repairs.
- Performed system failure test for backup power at both operations centers.
- Retrieved portable assets such as Portable Variable Message Signs (PVMS) so that they would have mobile, functional assets to deploy in the immediate aftermath.

Pre-hurricane weather monitoring strategies included:

- Ensured that each operations center is tuned to the approved 24/7 TV news station.
- Assessed Road Weather Information System (RWIS) station data and functionality.
- Participated in regular conference calls with the local National Weather Service Office.
- Monitored Hurricane Evacuation (HURREVAC) the decision support tool of the National Hurricane Program, administered by the Federal Emergency Management Agency (FEMA), and the NOAA National Hurricane Center.
TRANSCOM took the lead in coordinating across regional players throughout the storm response. This included conference calls, reviews of bridge/tunnel shutdown protocols and agreed upon actions, and agreeing to common language and messaging about the storm to the public and media. The 511 service was central to the traveler information strategy. NJDOT provided motorists with critical information about what to do in planning for the storm and also provided links to evacuation routes and emergency management sites like www.NJReady.gov where they could go to learn more about preparation for the arrival of the storm. Information was updated in real time.

NJDOT uses Open Reach database network in all of their operations centers – all roadway data is housed here and includes freeways, arterials, toll roads, and river crossings. Any type of issue that impacts a lane of traffic, including shoulder closures, is entered into the database. This system is also used by all of the transportation agencies in the TRANSCOM region, which allowed for transparency across agency lines and easy communication through a shared data system and data terminology. The Open Reach database was relied upon during the storm for daily status updates and regional condition reports that were delivered to the Governors of NJ and NY. Once sustained winds declined below 39 mph, crews began to deploy and assess roadway conditions and damage. Any and all conditions that were reported were entered into Open Reach.

The impact of the hurricane was beyond what they could have imagined, roadway damage was severe and public transportation was severely impacted. Statewide power and telecommunication outages caused by the storm severely impacted ITS operations and recovery. At 7am on October 30th, the morning after the storm, they were down to 30% of CCTV (95 of 317) working. Prior to the storm they were 91% (289 of 318). After the storm 25% permanent VMS (38 of 154) was operational, down from 94% (144 of 154) prior to the storm. NJ TRANSIT Rail service into NYC was almost completely shut down and the agency had to create satellite parking locations for temporary bus service into Manhattan.

The response was impressive, they were able to clear over 581 road incidents within 3 days, restored majority of ITS devices to full service within a week and repaired/restored nearly 1,100 traffic signals by Nov 7, just in time for a Northeast snow storm. Lessons learned from this experience include:

- Open Reach database functioned throughout the storm
- Conference calls became information exchange opportunities
- Working relationships were further strengthened
- ITS equipment is weather-resistant not flood-proof. Need to move critical devices out of flood prone areas.
- Many field sites, hubs, generators and VMS went down because of the lack of power, not from water damage.
- Buy more generators. Over a dozen portable generators have been ordered so that power is maintained at critical locations in the ITS network.

3.2.3 Fog/Low Visibility Crash in Virginia (Tim Martin – VDOT)

The Fancy Gap Mountain fog incident involved 95 vehicles with 17 different incidents. The route serves primarily truck traffic and travelers passing through from out of state. A fog alert came in at 5:56am from an RWIS station. The alert came in with visibility of 990.8 feet. The threshold for fog alerts being issued on the VSL is 1320 feet. Prior to the incident the visibility got as bad as 157.5 feet. Average speeds, even with the fog was high – over 65 mph.
The incident was detected at 1:17pm. Prior to the incident detection and verification, DMS signs posted a fog alert and for drivers to adjust speed, once the incident was verified (at 1:31pm), signs posted “accident ahead, road closed”. VDOT reached out to neighboring agencies as well as truck stops to alert them of the incident.

The incident involved a total of 95 vehicles, 17 separate accidents, 15 vehicles on the escape ramp and 3 fatalities. It lasted 10 hours and 42 minutes. Agencies involved included the Virginia State Police, Fire and Emergency Management Services (EMS) (including from North Carolina), Towers/Wreckers, Sheriff and local police. There were no pan-tilt-zoom (PTZ) cameras installed at the site of the incident – VDOT is in the process of installing these along with supporting infrastructure (fiber/electricity) at this location. In addition, there will be new paving markings, signage, and a public outreach campaign to reinforce the message that during foggy conditions travelers need to heed warnings and reduce their speed.

Q&A Session:

- (VA) You mentioned that in Virginia you notified truck stops – did you have that information pre-pulled together or did you have to pull it together?
  o Based on lessons learned from previous events where we did not have the full contact information for all stakeholders that may be impacted, the incident manager now has a contact list with all potential stakeholders – truck stops, schools, hospitals, etc., to ensure that we can provide information to them in a timely manner.
- (VA) What type of sensor are you using for visibility and variable speed limits in VA?
  o Different sites use different sensors.
  o Part of a new contract that is out for bid is to develop new algorithm for use with VSL.
  o VA General Assembly has approved VSL use within the state. The State Traffic Engineer will set the speed limits but regional traffic engineers have the responsibility to determine how they will be set.
  o VDOT does not expect the new system to be fully in place until summer 2015.
  o VDOT is also testing different colors on VMS signs to determine what color can best be seen in foggy conditions.
- (KC Scout) You incorporate NWS warnings into your ATMS – have you looked at incorporating earlier information including NWS watches?
  o In KC/MO there are frequent watches. Our local news coverage pushes out a lot of information on watches, so we didn’t think there would be a benefit to doing that with our system. This way we focus on advisories and warnings.
- (NJ) In the response to Super Storm Sandy – looks like NJDOT was a lead in the response efforts – how did you coordinate with emergency services?
  o NJDOT took the lead in a lot of areas, especially in regards to clearing roadways, but we were following incident command protocols and were integrated in decision making with incident management personnel. Our areas of responsibility were the roads – doing whatever we could to make them operational again as soon as possible. NJDOT staff is located at a regional emergency management operations center so people interact on a daily basis, which helps with collaboration when an event occurs.
- (VA) As part of your new statewide Transportation Operations Center (TOC) procurement, are you asking the bidders to coordinate system requirements for VSL?
  o Yes, the statewide TOC contract will coordinate system requirements for VSL but this will not be part of the new ATMS. Individual TOCs are going to be incorporated into the new statewide system incrementally.
(KC Scout) In your snow storm example, what day of the week did the storm hit and do you have any statistical data that compares the travel flow with a “normal” day?
  o The storm hit on a Thursday/Friday depending on the region of the state (the western region got hit with the snow first). KC Scout is conducting analysis with historical data to see if traffic flows on the days the storm hit were less.

(All) In North Carolina, we are behind compared to what we have seen presented today. All three presenters have spoken about the benefits of having media and public information/maintenance staff together in your TOC – how did you get there?
  o In KC we got there as a result of a major event that wasn’t handled very efficiently and resulted in significant backlash from the media and public. We took the criticism to heart and worked out a path to ensure better information would be provided in the future.
  o In NJ integration was strengthened with development of Open Reach database in 2006/2007.

3.3 Weather-Responsive Citizen Reporting and Social Networking
In this session, agencies provided updates on their existing and planned citizen reporting programs and social networking systems.

3.3.1 Wyoming’s Enhanced Citizen Assisted Reporting Program (Vince Garcia – WYDOT)
Wyoming was looking for a way to improve condition reporting at a low cost. The Enhanced Citizen Assisted Reporting Program (ECAR) provides a cost-efficient way to engage the public, improve 511, and provide more timely and accurate information to the traveling public. There are currently 400 participants; each is required to go through training to participate. They modeled their program after the National Weather Service’s weather spotter program. Callers will call into the TMC using a 1-800 number and they provide their ID number, road condition/situation, route, milepost, and direction of travel. They initially asked the caller to provide vehicle type to see if different vehicles – cars vs. trucks had different viewpoints but have since stopped asking for this data point as there was no significant difference in the data they were receiving. Program has resulted in more accurate and timely road condition reports. Future plans include recruiting more volunteers, getting better coverage along minor/arterial routes, and more comprehensive time of day coverage.

3.3.2 Utah’s Citizen Reporter Program (Lisa Miller and Leigh Sturges, UDOT)
The goal of UDOT’s program is to allow trained citizen reporters to report road condition information to the UDOT TOC for inclusion in the Travel Advisory Telephone System (TATS). The program is specifically for road and weather conditions and includes 145 different segments for reporting. Training for participants is provided online and in-person. Reports can be submitted using the citizen reporting mobile application. The reporting period is not year round; the focus is on the winter weather period which goes from October to April. Currently there are 50 UDOT reporters who provide reports on 38% of the routes. The information will go public this coming winter. Looking ahead, UDOT is thinking about developing cross-border components of the application in the future as well as possibility for uploading pictures.

The Citizen Reporter Program is undergoing an evaluation to provide a baseline from which to grow recommendations for future development, and setup some statistical tools for continuous performance management. Evaluation will look at the efficacy of citizen reporters, benefits to UDOT operations, and benefits to the traveling public. During the first season (Dec 2012 - Mar 2013) they trained 56 reporters with 31 actively engaged in the program. Reporters submitted 607 valid reports and were found to be
three times as likely to report on storm days. The primary reporting period covered Monday - Friday from 9am-5pm. In order to optimize the distribution of reports the evaluation team recommends recruiting to populate primary routes, recruitment from multiple sectors of the work force (temporal variety), communicating with citizen reports throughout the year to keep them engaged, emphasizing reporting even when weather is clear (consistent flow of info) and reporting post-storms.

3.3.3 Idaho’s Citizen Reporting Program (Tony Ernest – ITD)
Idaho Transportation Department (ITD) is launching a brand new program this winter to improve winter road condition reporting. The program was inspired by Wyoming DOT’s efforts and tweaked a little so that people can go online and report on conditions rather than call into the TMC. Winter weather road conditions are established by reports radioed in by maintenance crews – they are required to make daily reports and report as conditions change. ITD has found it hard to track the reliability of condition reports, and the public has complained about out-of-date information.

ITD’s program will tie into their 511 comprehensive website, which will include NWS winter weather warnings and reports from maintenance and snow plow drivers. The new system will allow for customized route mapping to show conditions along commonly traveled routes – reporters can save their routes into their profile and then send condition reports on routes. Routes can also be broken down into segments to allow for reporting of different conditions. The current plan forward is to recruit bus drivers who can report to their dispatchers, who can then upload conditions onto the website. ITD will provide a short training module.

Expected benefits include improved frequency of reporting, improved public interest in 511, more direct feedback from the public and better metrics to evaluate timeliness of reports from maintenance crews. ITD is not planning on implementing a mobile app as there is a lot of concern regarding driver distraction.

3.3.4 North Carolina DOT’s Social Networking System for Weather (Lisa Schell – NCDOT)
NCDOT launched 16 different Twitter feeds during the 2009 hurricane season, giving residents and visitors who may not have had access to landline telephones or computers the ability to get updates on road conditions via their cell phones. The department also relied on those feeds – which target regional areas of the state, heavily traveled interstate routes such as I-40 or I-95, and the ferry system – to alert motorists about dangerous driving conditions during the two snow storms North Carolina experienced in 2009.

Since that time, their presence on social media has grown – they now have five Facebook pages, 24 Twitter feeds, a YouTube and Vimeo video page, Flickr and Instagram for photos, and they are also using Pinterest and Soundcloud to augment their social media content.

Twitter, along with NCDOT’s YouTube and Flickr pages, served as critical communication tools during the debilitating rockslide that closed a seven-mile section of I-40 near the Tennessee border in October 2009, creating a 53-mile detour. They quickly saw the value in providing daily updates on work to clear the debris, as well as information on the detour route via Twitter. The clean-up effort took nearly six months, and social media enabled NCDOT to maintain public confidence during that time. NCDOT has decided, based on this experience to integrate social media into their crisis communications plans, as well as their regular communications plans.
Social media has become the most direct, cost effective and efficient way of reaching citizens in a crisis. NCDOT has learned that the public expects them to communicate emergency information in this way, and when they do, their reputation as a responsive, responsible, and valuable state agency is enhanced.

Another example is how the agency responded during Hurricane Irene. NCDOT transportation staff worked with their Communication Office to inform the public through social media and included:

- News releases about preparations
- Media interviews
- Tweets to thousands of followers
- Pictures posted to Flickr
- Updates on Secretary’s Facebook page
- Real-time travel information on website
- Videos posted to YouTube
- A dedicated NC 12 twitter feed to keep residents and tourists up to date on the progress of the highway repairs.

For the Twitter feed NCDOT saw an increase of nearly 1800 followers from the start of the hurricane until Oct. 20. Both the NCDOT feed and the NC12 feed received hundreds of re-tweets, from residents, businesses and media, including CNN and the BBC, and government agencies from FEMA to the British Consul.

Being engaged in social media helps to control some of the messaging and address rumors to ensure the right information is out there. Integrating social media with traditional media messaging is critical as well as providing linkages to more information. Playful tweets and posts get people engaged. The agency still managed to keep it professional and focused on safety, making the information more consumable by the public.

Q&A Session

- For agencies with mobile apps for reporting how are you handling the concern over distracted drivers and reporting while driving?
  - UDOT stresses in training that passengers, not drivers, should report while en-route, or that drivers should wait to report until they are in a safe place to do so. To date, UDOT has not had any complaints that an accident has occurred as a result of using the app while driving.
  - NCDOT uses social media – especially Twitter – to remind participants not to report while they are driving.

- In Wyoming and Utah, is the report information going directly to operators or through a DOT staffer?
  - In Wyoming the reports are given directly to the TMC operators over the phone. In Utah, report data is sent right to the weather room – this is the same process as the plow reports, RWIS reports. Information is shared informally with the operators.

- Are any agencies tapping into applications like WAZE (mobile navigation application)?
  - In Idaho we are aware of WAZE and watching how it develops but are not tapping into that information right now. It might be part of our mobile platform development in the future.
  - In North Carolina our local TV stations are already using WAZE and we are looking into it.
In Wyoming we haven’t really looked at this – with Google purchasing it, this information will be available on Google maps anyway.

- In Wyoming, you are using reports from DOT staff, any concerns regarding liability?
  - We have checked with the attorney general’s office and that office felt that there were no risks to liability but we have not faced a direct test yet.

- How do you determine what segment of the roadway the report applies to?
  - UDOT has segments broken down by shed area. We are using the same segments for the citizen reporting program. With this format some segments are a little longer than ideal – but we ask our citizen reporters to note the worst condition they are seeing so there are no surprises. In the future, we may break down some of the longer segments into smaller sections. In addition, citizen reporters can enter text comments to accompany their report.
  - WYDOT follows a similar approach to UDOT.
  - Idaho developed a public reporting format that is different than the maintenance segments as there was concern they would not understand how the segments were aligned.

- What metrics are agencies keeping to justify continued expansion of your WRTM programs?
  - Performance metrics are hard, especially for 511. In Idaho right now we’re tracking the simple things – how many people come to the website and tone of the comments received.
  - In UT as part of evaluation of WRTM program we are looking to define metrics. Our leadership is behind this and willing to invest resources in it – but still undefined from a performance measurement standpoint.
  - The same is true in Wyoming. Leadership is behind the program and feels the investments they are making are getting good value.
  - Social media tools are free to use so no need to justify. In North Carolina, communication officers are utilizing these tools as part of their daily job duties.

### 3.4 Weather-Responsive Active Traffic Management and Signal Control

This session provided an update on Active Traffic Management (ATM) and signal control strategies being deployed by agencies and how weather has been integrated in these strategies.

#### 3.4.1 Weather and ATM in Oregon (Galen McGill – ODOT)

ODOT is deploying ATM along OR State Route 217. As part of this deployment WRTM strategies are being included. The project encompasses a 7.52 mile stretch along OR 217 with high crash rate – over 200 crashes per year with most being rear-end collisions during peak periods. ODOT underwent a planning effort to look at potential solutions for this corridor in 2004. At that time recommendations totaled $1 billion – which was too high of a price tag. The agency went back to the drawing board to look for some lower cost solutions to help improve conditions immediately that can help move towards longer term corridor goals. ODOT looked at affordable operational improvements they can implement today, with immediate driver benefits, such as:

- Traveler information system
- Queue warning system
- Variable advisory speeds (advisory)
- Curve warning system
- Updated adaptive ramp metering
- Shoulder Widening
The anticipated costs were 1% of the original $1 Billion budget proposed for the long term solution.

One strategy deployed was weather responsive information for VSL. The goal is to notify drivers of adverse weather conditions by providing advisory speeds for different weather events (including visibility) using applicable messages on VMS. The system will be operator controlled, with guidance developed for what information should be displayed based on conditions. The curve warning system will also have weather responsive alerts that will activate at similar grip factor (road weather condition) thresholds as the VSL. ODOT will be conducting a weather responsive evaluation that will look at:

- Impact on mean speeds and speed distribution
- Impact on incident rates
- Driver compliance
- Comparison of weather-based speeds to congestion-based recommended speeds
- Impact on reliability

The plan is to turn the system on at the beginning of 2014.

3.4.2 Weather-Responsive Ramp Metering in Washington State (Vinh Dang – WSDOT)
There are many factors affecting the capacity of the roadway. Static factors such as roadway geometries are easy to handle. However, weather is not. Working with this dynamic weather factor, agencies need to pro-actively manage both the demand and the capacity sides of the equation to keep roadways operating at the optimum level.

In the Seattle metropolitan area, there is a peculiar weather phenomenon, called the Puget Sound Convergence Zone. The convergence zone is formed when Northwest winds after being split by Olympic mountain converges over the Puget Sound. As travelers enter the convergence zone in the winter, they often get caught by surprise going from a bare and somewhat wet condition into a sudden snowy condition. Note that typically when there is a widespread weather condition, WSDOT will not use VMS to provide road condition. However when the condition is unexpected and isolated as a result of the convergence zone effect, WSDOT will broadcast those conditions on VMS and any other appropriate ITS devices.

When traffic becomes heavy and operating speed starts dropping below free flow speed, WSDOT observed that drivers start changing lanes hunting for gaps to get away and ahead of the crowd. Similar behavior is observed during weather events (wet roadway surface, heavy rain, snow, etc…). Less-skilled drivers would slow down and maintain longer headway. Aggressive drivers, or drivers who think they have better skills or vehicles, would weave in and out of the gaps to get ahead. To address the wide speed variation, and speeding under bad weather condition, WSDOT uses variable speed limits that reflect the true operating speed under those conditions. WSDOT is not new to variable speed limit deployment. In 1998, WSDOT installed the first VSL system for the I-90 Snoqualmie Pass. In 2005, they installed the second system for the US-2 Stevens pass. These systems were installed to address speed limits during snow and ice events. Both were semi-automatic in a way that the system could collect operating speed and recommend a speed limit to the operator. If the operator concurs, he or she will display the speed on the sign. Speed limit ranges from 30 mph to 60 mph with 5 mph increments.

When WSDOT receives a forecast of severe weather, WSDOT will try to manage travel demand by encouraging travelers to make adjustments to their trips. The television stations in the area are doing a great job broadcasting traffic and road condition. They have direct video feed from WSDOT’s freeway cameras. Commuters in the area are accustomed to having traffic report daily in the morning and in the
afternoon. During major weather events, or major incidents, WSDOT works with the media to broadcast traffic and road condition as a way to manage travel demand before drivers make the trip. Collectively, the agency is not shy about advising people to stay home on snowy or icy days.

WSDOT has roughly 220 ramp meters in the Seattle metropolitan area. These ramp meters are demand management devices. They balance the need to serve ramp traffic with the available capacity in the system. Ramp metering helps by stopping the ramp demand platoon and release one vehicle at a time. For the rainy weather in the Seattle area, this makes the merge safer and smoother. WSDOT turns off the meter if they observe ice and/or snow on the ramp. This is to make sure traffic in the rolling queue never has to come to a complete stop (and maintain vehicle control). In this case, the operator would deploy a caution arrow or junction warning on mainline approaching those on-ramps.

WSDOT has also deployed some integrated corridor management (ICM) strategies during major weather events such as snow and ice. At network junctions or ramp terminals, operators increase the signal gap time to account for longer headway (to avoid signal gapping out too often). WSDOT has been actively managing the Reversible/Express lane schedule in response to blocking incidents. When the weather hits, the agency is ready to apply the same tactic. Mode shift is another ICM strategy that the agency is working on with transit agencies. During major weather events, light rails and commuter rails would operate on their normal commute schedule so the agency is looking at how to move people by transit.

3.4.3 Weather-Responsive Traffic Signal Management in Utah (Mark Taylor – UDOT)
Utah is the 34th largest state by population, however, by land area it is the 13th largest state. 80% of Utah’s population lives along the Wasatch Front, which is an area about 100 miles long and approximately 5 miles wide. There are approximately 1,900 traffic signals in Utah, where 60% are owned and operated by UDOT. What makes UDOT a bit unique is that all of the signals in Utah that are connected share the same communications network. This approach has fostered a team-building environment with all the traffic signal partners.

The UDOT Weather-Responsive Traffic Signal Management project has the following goals and operational objectives:

- Proactively manage traffic signal operations during weather events.
  - Maintain a high level of progression on the main-street.
  - Maintain an acceptable throughput for the existing conditions of the roadway.
  - Maintain equitable service to cross-street.
- Maintain operational strategies by:
  - Keeping cycle length and splits the same as used in “Normal Time-of-Day” plans.
  - Change only offsets and sequences due to reduction in “normal” speeds caused by the weather event.

The project developed special weather plans to change traffic signal timing along the study corridor (Riverdale Road), which included AM/PM peak and off-peak and no recall, minimum recall, and maximum recall plans. The project also included real-time traffic signal performance measures that allowed for fine-tuning of the weather plans once they were implemented. The project used Advance SmartSensor for dilemma zones, coordination diagrams, approach speeds, and volume counts. Overall the quality of progression was not severely degraded as a result of implementing the different weather responsive timing plan strategies, and UDOT was able to maintain traffic conditions similar to no-weather event levels. UDOT is looking to expand their weather responsive signal timing to other corridors as a result of the project’s success.
**Q&A Session**

- How did you develop the speed look-up tables in Oregon?
  - ODOT did some research internally, pulled examples from existing literature, and then customized them for what we needed.

- In UT, based on what you implemented last winter – how do you plan to take your approach to multiple corridors? It seems that there is a high-level of operational support required?
  - UDOT has been running weather timing plans since the Olympics – we just didn’t know how well they were working until now. We have a number of real-time detectors out there so based on the results we have seen so far we definitely want to take this approach to other corridors.

- (UT) How do you implement the weather plans?
  - We have tailored weather plans around AM and PM peaks and off peak so when the storm hits we run the plan tailored for the time period.

- (UT) Has anyone tied weather responsive plans into adaptive signal systems?
  - What UDOT is doing is human-in-the loop adaptive signals – so not quite fully adaptive signal system integration. We are looking to identify ways with the use of the Purdue diagrams to apply this to our adaptive signal system.
  - Adaptive signal systems may not prove to be a very effective tool here as they can take a long time to implement the change which may limit an agency’s ability to be proactive.
  - There may be ways to override the adaptive signal system to push out changes quickly but this will require manual intervention.

- In WSDOT, how effective is ramp metering during weather events? Do you operate it differently?
  - Ramp metering system has helped break up the flow of traffic and reduce incidents. In addition we use junction warning and lane merging warning alerts to caution drivers and encourage them to move over to the next lane.

- In OR, why did you decide to go with advisory speeds vs. regulatory speeds on your VSL?
  - We participated in a peer exchange with FHWA with representatives from Virginia, Missouri DOT, and Minnesota DOT and after discussions with them about how they deployed their systems and communicated to the public about the speed limits we felt that starting with advisory was the best bet.
  - ODOT does have the legislation in place that would allow for regulatory VSL.
  - For most agencies regardless of whether the speeds are advisory or regulatory enforcement is coming in the form of reckless driving and not speeding.

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**3.5 Data Resources for Traffic Managers**

Understanding weather data sources is an important element of WRTM. There are many sources available today that vary in cost, complexity and usefulness. This session provided participants with information about various weather data sources available to traffic managers and how they can be integrated within the traffic management context.

**3.5.1 Weather Information for Traffic Management (Ralph Patterson – Narwhal Group)**

TMC user groups include: incident management, maintenance, weather operations, traffic engineers, signal timing engineers, operators, ITS maintenance, public information officers, and traveler information services. There are many sources of weather data – including surface observations (RWIS, SNOTEL, RAWS); remote sensing (Satellite-based, radar); numerical models (atmospheric, surface/road, traffic); traffic data (cameras, TMD); field observations (government personnel/citizen reporting, social
media); and mobile observations (CAN bus, weather instrumentation). The bottom line is that not all of this data is easily digested by TMC staff. You need specialized skills to understand, interpret, calibrate, and utilize the data. For example, surface weather data is more than just RWIS. You can also use traffic data as proxy for weather and road conditions. Data challenges include:

- Surface observations require extensive metadata and can be maintenance intensive.
- Remote observations can be difficult to interpret, requires high bandwidth, and can be difficult to archive.
- Numerical models require specialized staff to interpret them.

Forecast options include:
- National Weather Service (NWS)
- Private sector
- Academia
- Television
- Radio
- Internet
- Phone apps
- Printed media.

A lot of television/internet/apps are recycling content from the NWS.

For traffic operations the important stuff includes road weather forecasts, NWS watches/warnings and point forecasts. Anything outside of 48-72 hour window is too far out to be relied upon. Meteorologists provide skill set to help operations staff interpret the data, define and identify impacts to operations, communicate impacts and provide decisions support, train operations personnel, develop RWIS deployment recommendations and plan, and overall add value to TOC weather-related operations.

Recommendations:
- As you deploy new weather technology, make sure you have the capabilities to maintain it, the knowledge to calibrate it, understanding of what it means, and financial fortitude to upgrade and maintain it.
- If you need weather data and forecast information (and you do) bring on the proper staff. Your operators and engineers should not be expected to shoulder the burden of interpreting data.
- Data are as data does, keep extensive metadata on your devices.
- Perform a needs analysis.
- Develop and maintain a plan for RWIS deployment and maintenance, mobile data integration, as well as data collection, archiving and dissemination. Update the plan on an annual basis but stick to the plan.
- Develop performance measures and a performance management plan. Communicate.

3.5.2 Traffic Data Resources for WRTM (Deepak Gopalakrishna – Battelle)
TMC’s are typically the focal location for the data that support WRTM, but other agencies and locations also may be involved in managing, acquiring, processing and adding value to the data. Road Weather Information Systems (RWIS) and Environmental Sensor Stations (ESS) incorporate roadside sensors that measure precipitation, wind, visibility, and temperature; support video cameras; and include pavement surface and subsurface measuring devices that inform TMC operators of current conditions along
segments of roadway. This allows operators to detect flooding, snow coverage on roadways, freezing pavement surface conditions, wind and low visibility conditions that inform traffic management and road maintenance decisions and guide advisory information disseminated by the TMC. TMCs perform critical functions to manage traffic during all weather conditions. Traditional traffic data during weather events includes:

- Traffic stream data: traffic volume, speed, density; vehicle type (size, weight, profile); travel times and delays, and predictability and reliability of flow
- Asset information – inventory of assets: pavement, bridges, sensors, cameras, signs, vehicles, equipment, and materials.
- Infrastructure characteristics and conditions: structural conditions, weather vulnerability, power and communication links.
- Traffic event data: collisions, crashes, road closures and restrictions, construction, and scheduled events.
- Other agency data: TMCs, State DOTs, other agencies.

Traditional sources of traffic data include: traffic monitoring devices (cameras, radar, loop detectors, probe data); data archives (state transportation databases, national databases, and university archives); and reports from observers (state patrol, DOT motorist assist patrols, DOT maintenance crews, and traveler observations). Data resources include crowd-sourced data, probe data, and new data visualization tools. It is important to note that a small population of users can produce vast quantities of data. The National Center for Atmospheric Research (NCAR) works closely with the USDOT to help develop tools, such as the MDSS, that can assist state transportation agencies to more effectively manage their operations during weather events. See: [http://ral.ucar.edu/wsap/themes/surf_trans.php](http://ral.ucar.edu/wsap/themes/surf_trans.php).

**Q&A Session**

- The northern tier States are very concerned with weight restrictions. When we talk about data – should we expand the discussion to seasonal weight restrictions and how weather is a factor there?
  - Subsurface pavement temperatures can be a critical data point in the spring for the northern tier states for when weight restrictions should be put in place.
    - This was reviewed as part of the CLARUS evaluation and should definitely be considered where appropriate.
- In North Carolina, our agency is working on a pilot program to post weather information onto the DMS when the signs are not in use for traveler information. Have any other agencies done this?
  - In Missouri, our agency’s stance is that a blank board is a wasted resource. We post a series of public service announcements that are posted. We use a different font and lettering style to post public service messages vs. regular warnings to try to help travelers distinguish between the two message sets.
  - In WA State, we have not posted about weather on the DMS signs unless it is an unexpected event. Our policy is to only post to the signs when there is an action required by the driver.
- How can we effectively communicate the difference between general weather and road weather – how do you get out the road specific messaging?
  - Having meteorologists as part of the integrated weather team/transportation group will help to develop the messaging you need.
In addition, NOAA staff can support agencies with this. The NWS will incorporate road information into their weather reports. DOT agencies need to provide direction to NWS as they do not have the roadway expertise.

3.6 Weather Responsive Traveler Information Systems
This session provided a discussion on recent developments in providing traveler information and advisories focusing on emerging concerns such as commercial vehicles, long-distance travel and road condition reporting.

3.6.1 Road Condition Reporting – Developments and Challenges (Dave Huft – SDDOT)
South Dakota DOT’s RWIS was put in place in the 1990s. SDOT’s 511 service was launched in 2002 and the Safe Travel USA website was launched in 2006. Traveler information is fed into the integrated road information system (IRIS) and then flows out through the 511 system. The 511 system has traveler information, landmark references, and detailed conditions. Road condition reports come in from SDOT maintenance staff. They are required to report in three times a day during Oct-May and file additional reports as weather conditions require it. In addition to SDOT staff, there are 150 reporters using SDOT’s online tool to report conditions. SDOT has developed a 511 mobile app that is available on the Android market now and will be available for iPhones in the fall. In addition to the main 511 system, SDOT also has ClearPath 511 which is a free subscription-based service that can send emails or text messages with road closures, travel advisories, flooding alerts, and customized route information.
Challenges facing SDOT include limited observation and reporting periods (as they cannot staff 24/7) and limited geographic coverage.

Looking ahead, plans for improvement include implementation of a weather responsive traffic management system that will use a maintenance decision support system (MDSS). The MDSS will predict road conditions, track applied maintenance, consider available resources, and recommend treatment type, rate, and timing. Expected outcomes include reduced material, fuel and labor costs, providing equal or better levels of service, and improved management tools. Mobile data collectors are installed in approximately 100 snow plows. They will observe weather and road conditions, and measure air temperature, surface temperature, plowing, treatment type, and application rate.
Development of this project will start October 2013 with deployment and evaluation planned for July 2014-September 2015. SDOT is working on how to communicate their predictive capability to the public without setting false expectations.

3.6.2 Commercial Travel and the Role of Road Weather Information (Vince Garcia – WYDOT):
Commercial vehicle operators have a big impact on WY. I-80 is a major east-west commerce route that has about 11,000 vehicles a day, of which approximately 50% are commercial vehicles. I-80 and I-25 both have a high number of truck blow overs. WY has frequent severe weather events during the winter months, which have a significant impact on commercial vehicles especially when the roads have to be closed. WY does have legislation in place that allows WYDOT to use VSL to post regulatory speeds based on weather emergencies.

WYDOT has met with the I-80 Corridor Coalition and commercial vehicle operators (CVOs) to discuss what information is valuable to CVOs in order for them to make decisions about their routes. CVOs asked for a one-stop shop – current weather/road conditions, construction information, and forecasted conditions. Based on information provided in the forecast they can then make strategic decisions on whether to push shipments, delay shipments, or re-route trucks. WYDOT develops 12, 24, 36, and 48-hour impact forecasts that include wind speed/gusts, visibility, and surface conditions. These forecasts
are specifically targeted for CVOs and include national weather service watches and warning information, as well as provide the information on a map and text format. CVOs and Wal-Mart specifically were very willing to work with the DOT and now have a number of different carriers using the system even without having to advertise it. WYDOT is extending the forecasts out to 72 hours and will include a link to truck parking (UT built truck parking map – DOT as well as private parking areas) and wind grid based on the CVO’s requests.

**Q&A Session:**

- What do we need to be aware of when communicating information to the public – especially when it’s predicted information?
  - You have to be cautious about providing information too far out into the future as the information won’t be reliable and the public will lose faith in the information. In SDDOT we limited future predictive information. You also have to take into account what level of maintenance you can provide and whether you will be able to keep up with the storm.
    - This is a topic that is worthy of future discussion → how do you communicate the relative uncertainty of the information you provide and changes in the forecast overtime.
- In Wyoming, what wind speeds are deemed dangerous for trucks and when do you issue a restriction?
  - With winds of 35 mph we issue a warning, at 50 mph we issue an advisory for caution, and at 65 mph we restrict truck traffic. If there is a blow over all truck traffic is restricted regardless of current wind conditions.
  - WYDOT has the authority to close the roads – we don’t have to rely on State Police.
  - We do not have any gates to restrict access to the roads so we rely heavily on our DMS to inform drivers of closures.
- Have you had to justify the costs associated with the detailed forecasts to your management?
  - We have not captured specific metrics on benefit/costs but our agency leadership has been supportive. Certain areas in WY are prone to high wind gusts so we are now able to predict potential incident locations.
- How is the information shared with CVOs?
  - We have set up a secured website and sent them a link to it. We are hesitant to share with general public to avoid increased demand.
- What does the link to truck parking include?
  - Provides details on map which includes what facilities are available at the truck parking locations.

### 4.0 Facilitated Group Discussion – Improving Organizational Capabilities for WRTM

Participants engaged in a discussion to define gaps, successes, lessons learned, and areas of improvement related to their capabilities for WRTM. Capability maturity is defined as a consistent and structured evaluation or assessment of a process. AASHTO’s Systems and Operations Management Capability Maturity Model (SOM CMM) has been developed to guide an agency towards a higher level of implementation, standardization, and return on investment within the SOM field. Building off of the
framework shown in Table 3 below, the discussion focused on applying this model to improve organizational capabilities for WRTM.

Table 3. AASHTO Systems and Operations Management Capability Maturity Model

<table>
<thead>
<tr>
<th>Dimension</th>
<th>Level 1</th>
<th>Level 2</th>
<th>Level 3</th>
<th>Level 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Business Processes</td>
<td>Processes related to SO&amp;M activities ad hoc and un-integrated</td>
<td>Multiyear statewide SO&amp;M plan and program exists with deficiencies, evaluation, and strategies</td>
<td>Programming, Budgeting, and project development processes for SO&amp;M standardized and documented</td>
<td>Processes streamlined and subject to continuous improvement</td>
</tr>
<tr>
<td>Systems &amp; Technology</td>
<td>Ad hoc approaches outside systematic systems engineering</td>
<td>Systems engineering employed and consistently used for ConOps, architecture and systems development</td>
<td>Systems and technology standardized, documented and trained statewide, and new technology incorporated</td>
<td>Systems and technology routinely upgraded and utilized to improve efficiency performance</td>
</tr>
<tr>
<td>Performance Measurement</td>
<td>No regular performance measurement related to SO&amp;M</td>
<td>SO&amp;M strategies measurement largely via outputs, with limited after-action analyses</td>
<td>Outcome measures identified and consistently used for SO&amp;M strategies improvement</td>
<td>Mission-related outputs/outcomes data routinely utilized for management, reported internally and externally, and archived</td>
</tr>
<tr>
<td>Culture</td>
<td>Value of SO&amp;M not widely understood beyond champions</td>
<td>Agency-wide appreciation of the value and role of SO&amp;M</td>
<td>SO&amp;M accepted as a formal core program</td>
<td>Explicit agency commitment to SO&amp;M as key strategy to achieve full range of mobility, safety and livability/sustainability objectives</td>
</tr>
<tr>
<td>Organization/Workforce</td>
<td>Fragmented roles based on legacy organization and available skills</td>
<td>Relationship among roles and units rationalized and core staff capacities identified</td>
<td>Top level management position and core staff for SO&amp;M established in central office and districts</td>
<td>Professionalization and certification of operations core capacity positions including performance incentives</td>
</tr>
<tr>
<td>Collaboration</td>
<td>Relationships on informal, infrequent and personal basis</td>
<td>Regular collaboration at regional level</td>
<td>Collaborative interagency adjustment of roles/responsibilities by formal interagency agreements</td>
<td>High level of operations coordination institutionalized among key players – public and private</td>
</tr>
</tbody>
</table>

Business Process Considerations

- WRTM related projects have to be built into agency 5-year strategic plans.
- The reality is that for many agencies, we cannot build roads anymore so there is increased focus (and therefore opportunity) for innovation. Agencies need to put more focus on these kinds of projects.
- Incorporate WRTM into ITS architecture.

http://aashtosomguidance.org/one_minute_evaluation/
• MAP-21 will require metrics – projects will need to be defined around things that are tangible. WRTM projects will need to look at how to meet this requirement. Agencies know the costs so may be able to show some benefits through user delay cost reductions.
  o Missouri DOT (MoDOT) has developed a performance-based measurement system.
• Operations Academy provides opportunity for agency leadership to appreciate value of operations role and benefits of collaboration.
• Agencies can define what is required as part of projects – prepare a strategic transportation management plan to help guide the process.
• Capitalize on successes – for example, UDOT has been able to successfully demonstrate benefits and value of ITS investment. Going forward, all construction projects will include a 5% ITS investment to support/improve infrastructure.

Challenges
• Lack of data and benefit-cost information to support WRTM.
• Matching up weather elements to DOT decision processes.
• Infrastructure investment – RWIS and other necessary infrastructure are expensive – but will they be needed 5 years from now?

Systems and Technology Considerations
• Implementing in stages helps to phase out the costs and focus on doing a smaller set of system upgrades than a large-scale multi-system approach.
• Small success stories will go a long way with agency leadership and help you to build momentum.
• Engage stakeholders – the people who will use the system, be part of operating the system/responding to the system, will get benefits from it, and will provide information to it.
• Recent trend within DOTs to hire consultants for specialized expertise and data analysis rather than trying to maintain internal capabilities.
• Agencies need to be able to trust their forecast data.
• In Wyoming during the summer months, forecasters help to maintain the equipment in the field – this has led to a better understanding of how the equipment operates and improved up-time.
• Where you can, develop templates for common tasks or processes that will be deployed across multiple tasks/areas.
• Deploying a WRTM system is more than just the device – you have to have the communication in the field and ability to communicate back to the DOT. IT requirements need to be factored in when deploying equipment.
• Resiliency in this arena is critical – equipment and system has to function in extremes.
• Future of weather forecasting may be with probabilistic forecasting – to try to help quantify the uncertainty that accompanies it. The question here then for agencies is are you prepared to develop thresholds for actions based on a probabilistic forecast? For example, in Salt Lake City, the airport will staff up for plowing when there is at least a 20 percent chance of plowable snow.
• Ensure there is a feedback loop in place from operators back to forecasters – this will help to improve future forecasts.
• Think about how you define success or failure – when you are working in a traditionally reactive program and you try to be proactive and have a false alarm will these be deemed a failure?
• Integrate with the NWS – both data and camera feeds.

Performance Measurement Considerations
• User delay costs
• Recovery time after the storm
• Maintain a desired speed during the storm
• Incident rates and clearance times
• Response and resource capabilities

Culture Level Considerations
• Work across jurisdictional/organizational boundaries.
• Collaboration is critical.
• Share best practices and participate in peer-to-peer exchanges.

Organization/Workforce Considerations
• Provide opportunities for different teams/disciplines to work together – and not just when you need them to do it. Provide cross-training and opportunities for collaboration to create a one-team environment.
• Having an agency leader as a champion will help set the stage for what is capable.
• Consultants and contractors can help fill the gap for targeted or specific skill sets.

Collaboration Considerations
• Maintenance and Operations
• Public Safety/Incident management/Law enforcement
• Universities
• NWS/NOAA
• Neighboring states/agencies
• Corridor coalitions
• Other modes like transit
• Non-traditional partners – hydrologists etc.

5.0 WRTM and Connected Vehicles
This session provided an update of WRTM and connected vehicles and included an example from Michigan DOT on how they are using mobile data for WRTM.

5.1 Road Weather Management Program (RWMP) and Connected Vehicles Research (Roemer Alfelor – FHWA):
Connected Vehicles (CV) are at the core of U.S. DOT’s current 5 year ITS Strategic Research Plan. Road weather is very much a part of the CV program. The vision of the weather element as part of this program is two-fold: obtain a thorough picture of current weather and road conditions by including mobile sources, and improving weather-related decision support tools to mitigate safety and mobility impacts of weather. Weather and road condition observations will include: barometric pressure, windshield wiper setting, headlight status, speed and heading, location and elevation, hours of operation, brake status, stability control, steering angle, and differential wheel speed.

Road weather connected vehicle applications include: enhanced maintenance decision support, information for maintenance and fleet management systems, weather-responsive traffic management (VSL, signal timing optimization, motorist advisories and warnings), information for freight carriers, and information for routing support for emergency responders. Another project is the weather data
environment (WDE), which involves the development of a database environment that will manage and archive real-time weather data from both static and mobile sources, incorporate VDT functionality, support the development of connected vehicle applications, and integrate with other real-time data capture and management program environments.

5.2 Integrated Mobile Observations Project (Sheldon Drobot – NCAR):
The Integrated Mobile Observation (IMO) project will demonstrate the usefulness of mobile data for road weather applications through the development and testing of CV applications. We will be using a vehicle data translator (VDT) to support the connected vehicle application and working with three States – Minnesota, Michigan, and Nevada. A lot of cars tell us something about current weather conditions like air temperature. This will take it to the next level with other vehicle measurements – for example, the position of the steering wheel can tell us something about weather conditions – as conditions change, so does how people hold the steering wheel.

The integrated mobile observation project will build upon the data we are able to collect from RWIS and enhance it with vehicle data. The VDT will utilize research undertaken as part of the Clarus initiative and work on new ways to integrate the data with a key focus on the quality control of the data. Select roadways will be divided into pre-defined one-mile segments and data will be updated every 5 minutes including average temperature, speed, and percent of vehicles with their wipers activated. The project approach will be to combine mobile and ancillary data inputs into outputs of pavement conditions, visibility, and precipitation. Vehicle data provides an opportunity for higher fidelity and give distinction between snow cover vs. icy conditions.

5.3 Using Mobile Data for WRTM in Michigan DOT (Steve Cook – MDOT):
With connected vehicles you have to be a bit of a visionary – you have to figure out how to pull in all the data, process it, and then find a way to use it in a way that is functional for a DOT. RWIS Architecture could change based on current and future mobile technology capabilities. We need to know the right balance between RWIS & mobile data using RWIS as your control or “ground truth” for data quality checks and balances. What is the balance for greatest return on investment? Not sure yet, but MDOT is doing a study to look at this right now – results are expected in July 2014.

As part of the Integrated Mobile Observations project, MDOT has deployed Smartphones in snow plow trucks and light/heavy duty MDOT vehicles. MDOT has also established an agreement with Ford to allow for diagnostic data to be transmitted through Bluetooth as well as pictures. Potential connected vehicle applications include: data quality checks (ground truth - RWIS stations & third party speed data), targeted individual messages, travel times and incident updates, performance measurement/management, in-vehicle alerts, vehicle/device health monitoring, and vehicle diagnostics. MDOT is looking ahead to ITS World Congress 2014 that will be hosted in Detroit to really demonstrate some of our connected vehicle application development.

Q/A Session:
- Outside of Smartphones, are there probe devices that can pull data from public vehicles?
  - You can get speed/volume data from Bluetooth detectors but you won’t be able to get CAN data or surface data.
  - You could also use microwave detectors.
- The full implementation and benefits from connected vehicles are still years out. What opportunities are available to agencies now to improve decision making?
MDSS is the only tool right now that exists to support this. MDOT has two different MDSS systems and has recently put out an RFP to install Atmospheric Boundary Layer (ABL) GPS detection devices on snow plow vehicles to integrate with one of the MDSS and provide radar and treatment recommendations to the plow driver.

- How do you see vehicle observations being used for prediction/MDSS?
  - As part of our work with FHWA, MDOT is looking to take vehicle observation data and provide traveler information.
  - Data will be used to help refine forecast simulations.

- Infrastructure to collect data in CV program has to be supported and maintained – how do you see that happening?
  - In MDOT we know we don’t have the funding to install roadside equipment (RSE) at every intersection so this is something we are looking at closely. Dedicated short range Communication (DSRC) is an option for safety messages, but for other messages cellular or Wi-Fi is good enough for what the DOT wants to do.

- Where do the insurance companies fit in with this?
  - Insurance agencies are involved in the discussion regarding connected vehicles and data. The reality is that DOTs and insurance companies are going to adapt and change in order to respond to a CV system. There are a lot of unknowns here – and potential for some significant changes in how things are done. For example, roadway signage could be reduced with in-vehicle signage and warnings.

### 6.0 WRTM Analysis, Modeling and Performance Evaluation

This session provided an overview on WRTM analysis, modeling and simulation methods and described developments with the Weather-Responsive Traffic Estimation and Prediction System (TrEPS) model.

#### 6.1 Recent Advances in WRTM Analysis, Modeling and Performance Evaluation (Roemer Alfelor – FHWA):

There are three levels of traffic analysis modeling – macroscopic, mesoscopic, and microscopic. Macroscopic analysis of weather and traffic has the ability to model large study areas, use the flow, speed, and density measures to provide simple representations of traffic behavior in that network, and does not require detailed data such as driver characteristics. The models can typically be set up quickly and analysis is not time consuming to complete. Macroscopic models, however, cannot model detailed behavior in individual vehicle movements. Microscopic analysis is intended to simulate the movement of individual vehicles, driver behavior data is essential to simulate traffic conditions with the highest accuracy, uses car-following models, and longitudinal motion models, and allows for stochastic analysis of traffic. Microscopic models require substantial amounts of roadway geometry, traffic control, traffic pattern, and driver behavior data and each simulation can take a significant time to run. Mesoscopic analysis allows you to analyze larger geographic areas than microscopic analysis while still providing some of the detailed data that macroscopic analysis cannot provide. It allows for analysis of road segments, multiple routes within a network, basic signalized intersections, freeways, and ramps. Some complex traffic features such as sophisticated traffic signals cannot be well simulated with this level of analysis.

Performance evaluation ensures that the WRTM strategy is having the desired effect and outcomes, provides information to prioritize resources and justify future investments, provides hard evidence of performance and benefit, and encourages wider deployment of WRTM strategies serving national transportation goals. Performance evaluation includes mobility analysis, safety analysis,

Traffic analysis models exist to account for weather. Traffic and weather data are available to conduct analyses and develop weather-sensitive traffic models. Performance analysis needed to evaluate WRTM strategies. Much research has been done but more is needed to develop and validate models for traffic analysis and performance evaluation of WRTM strategies.

6.2 Implementation of Weather-Responsive Traffic Estimation and Prediction System in Utah DOT (Bobby Haas – SAIC):
Traffic Estimation and Prediction System (TrEPS) is a dynamic traffic modeling and assignment tool that estimates road-specific traffic conditions over broad geographic areas. TrEPS models individual roads, individual vehicle movements, vehicle movements governed by flow models, and vehicle paths governed by optimization models. The primary output is a collection of vehicle trajectories.

Weather-responsive TrEPS (Wx-TrEPS) includes weather adjustment factors to estimate impacts of weather on estimated and predicted conditions. Recent applications of Wx-TrEPS include projects in Long Island, NY; Chicago, IL; Salt Lake City, UT; and Irvine, CA. These studies used the Wx-TrEPS model to estimate effectiveness of different WRTM strategies including demand management, variable speed limits, and optional detour VMS.

The Utah DOT implementation will use Wx-TrEPS to analyze and evaluate weather responsive traffic signal timing plans on Riverdale Road in Ogden, Utah both offline and in real-time. Preliminary application compared performance measures at link, intersection, and corridor level with and without the use of weather-responsive signal plans. The performance measures include travel time, throughput, stopped time, and travel time reliability. Results show a 3.63 percent reduction in travel time and 13.47% reduction in total stopped time as a result of implementing the weather responsive signal timing plans. Next steps for the UT project include developing and calibrating a smaller network for real-time analysis, integrating Wx-TrEPS into UDOT’s signal timing planning and operations, and using the model for signal control decision-making during the coming winter. UDOT expected the weather to have a negative impact but what the models are showing is that you can reduce those negative impacts.

Q/A Session:
- For your snow and weather event response plans have you assumed a constant travel demand?
  - For the evaluation purposes yes, but we understand that in real-time we will see traffic volumes decrease as people become more aware. So far, we have completed the offline evaluation – this winter UDOT goes live and we’ll do a real-time evaluation.
- In the analysis, modeling and simulation charts you call out snow and rain but you don’t include fog. Is this intentional? Fog can contribute to a high number of crashes and should be included more in these types of discussions.
  - The charts are a summary and example. There have been studies done on fog they were just not incorporated into this set of materials.
- As far as the Wx-TrEPS deployment – is there a plan within FHWA to move this forward and opportunities for other states to do this?
Part of the goal of this meeting is to encourage agencies to start looking at and applying some of the tools that are available to understand how weather affects traffic flow on highways and how to evaluate them. With that said, there are no program funds for future deployments.

- So how do agencies really do this then?
  - UDOT is in the process of forming a team to look at how to market what we have done with our weather responsive traffic signals.
  - UDOT was selected by AASHTO’s Technology Implementation Group to develop a lead state team to share UPlan application with other agencies. For more information visit: [http://tig.transportation.org/Pages/UPlan.aspx](http://tig.transportation.org/Pages/UPlan.aspx) or contact Mark Taylor.

7.0 Facilitated Group Discussion - Integrating Maintenance and Traffic Operations during Weather Events
This session provided an opportunity for participants to engage in an open discussion about integrating maintenance and operations, identify challenges that their agencies have or currently face, and discuss best practices and lessons learned.

Are data needs really different for maintenance and operations staff?
- Data needs are not different, maintenance and operations staff doesn’t always share data and situational awareness. This becomes a critical issue during events. This includes social media.
- Operations and maintenance staff need to sit in the same room and talk about needs.

Do both groups understand each other’s operations?
- Many maintenance groups are called operations groups.
- For one agency – anything that impacts the roads the TMC will take the lead in coordinating a response. This is a result of their development of an integrated strategic plan.
- In Wyoming, TMC operators dispatch staff as needed – this includes maintenance and traffic management staff. One group that often does not understand the impact of the weather in response is the safety patrol – they need to be brought into the discussion as well.
- North Carolina has struggled getting all of the stakeholders to see the value of sitting together and sharing ideas. NCDOT has a facility that can accommodate staff from all agencies which is used during any state of emergency, but outside of those very high-profile events it is hard to get everyone to make time to discuss the day-to-day needs.
- Co-location is a critical component in response.

What are some examples of coordination?
- In Wyoming, forecasts are provided to the TMC and transportation office but they haven’t really done a good job of communicating the information directly to the maintenance staff to allow for a more direct feedback loop on the information that is shared with all three groups.
- In Utah, meteorologists provide information to traveler information and maintenance staff. Both sets of staff are then able to review prediction, road conditions, and make determinations about what they need to do based on the precipitation forecasts. In addition they package a sub-set of this information for the public information office and set targets for reduction in traffic flows.
• Utah experienced some equipment functionality challenges with LEDs and the snow sticking to them. Have been able to work with meteorologists to predict when conditions will cause this to happen and then can proactively ramp up with maintenance support to reduce the occurrence.
• In Missouri, new maintenance crews are brought into the TMC to see operations in action. MoDOT is working to relay a team environment and open the dialog early.
• South Dakota DOT relies on their MDSS to determine what roads will close and traffic management staff works based on what the model is able to tell them about. The MDSS is the glue that holds everything together.
• In Oregon, maintenance, operations, and dispatch are all co-located in the transportation operations center. This setup has worked well for ODOT, there are no coordination issues.
• The Delaware Transportation Incident and Event Management Plan⁶ has become a critical document in defining roles and establishing coordination amongst agency staff.
• In New Hampshire we have had greater success collaborating in urban areas vs. rural areas. The operations staff has had to work with maintenance staff to demonstrate that they were capable of supporting them. Part of the disconnect between the two groups is the different seasonal needs. NHDOT is moving towards a centralized system so this should keep the lines of communication open year round.

How do we advance integrated operations and maintenance?
• Training/peer exchanges.
• Demonstration of value.
• Continued cross-education of what each of the groups does so that opportunities for collaboration can be made clear.
• Establish a collaborative environment and set the tone through the leaders of your agencies/divisions.
• Include state patrol and NWS as stakeholders in these discussions as well. For major events you also have to think about non-traditional stakeholders including different modes.

8.0 Recommended Action Items
Following are the suggestions/focus areas obtained from the participants during the open discussion on the action items the FHWA Road Weather Management Program should pursue in relation to WRTM:

• Provide information and guidance on how weather fits into the CFR 1201 Rule.
  o Information on Final Rule 1201 is available from: http://www.ops.fhwa.dot.gov/1201/
  o FHWA has distributed to all participants a flyer on assessing conformance with Title 23 Highways [23 CFR] Part 511 Real-Time System management Information Program.
  o Ray Murphy is the FHWA lead for this, his contact information is:
    ▪ ray.murphy@dot.gov
    ▪ 708-283-3517
  o FHWA plans to conduct review meetings with State DOTs to review and discuss compliance.
  o Agencies will need help in defining quality and performance to meet compliance requirements.
    ▪ FHWA will consider hosting a webinar on this topic.

• Liability – especially related to connected vehicles (send NCSL report on liability considerations for road weather data to Nancy Powell and the participants).
• Work with the I-95 Corridor Coalition to share best practices about how they manage significant events across multiple agencies. Help to define a common language about roadway conditions – there is a need for some standard language and integration of applications and websites across agencies.
• Need to put hydrology on the topic map. Water is what takes out roadways.
  o This would be a good webinar topic.
• Develop guidelines for priority of messages on DMS boards with requirements or recommendations on what information should be posted.
• Provide guidance on consistent roadway conditions reporting through 511.
• Provide the AASHTO Systems Operations and Management (SO&M) Capability and Maturity Model (CMM) link: http://aashtosomguidance.org/

9.0 Summary of Participant Feedback
Following is a summary of comments and recommendations written by the participants on the survey forms distributed during the meeting.

• Weather Responsive Citizen Reporting presentations and the real-world experiences presentations provided good information to use as best practices for each state. These were greatly informative and the facilitated group discussion allowed for interaction and idea exchange between peers.
• Understanding how social networking works in real-world situations helped to see how it could be used as a viable option for implementation, although some found that it was not useful being that is already widely used.
• Every presentation shared useful information, but some of the presentations had too much detail and instead should have focused more on lessons learned, shortfalls/gaps, and successes. Modeling is an area that was not useful to some.
• More discussion on real-world implementations of WRTM and estimating benefits of WRTM projects would be beneficial.
• Flooding as a topic could have been expanded upon.
• Missing the opportunity to share with partners such as NOAA/NWS. More focus on joint research.
• More in depth information is needed on DMS messaging. It would be useful to have information available about specific DMS messaging instead of each state developing its own messaging. Currently it is not used to warn of severe weather, but should be.
• Looking to do more WRTM for less severe weather conditions, also examining WRTM strategies, e.g. variable speed limits, innovative warning dissemination techniques and traffic estimations.
• Visiting a TMC or operation center would be a good thing to pursue in the near future as a best practice, also an overview of each TMC’s work policies and procedures could be useful.
• Research on variable speed limit algorithms. Standard Research for friction measurements by sensors. Technology/knowledge transfer of SHRP2. Need DOT project champions!
• Perhaps look at stronger interrelationships between weather and safety and mobility related performance measures. Tie to crash rate and serenity. 120V rules guidance.
• It would be very helpful if FHWA could publish the “Top 5 Easiest Strategies to Implement.” Based on B/C and minimal resource drain, i.e you don’t need to build a new organization around
the strategy. Publish benefits/evaluation results from any of the WRTM projects as they are available.

- Provide a better format to exchange best practices between organizations. Perhaps webinar or some other tool to engage the group on a more regular basis. More time for discussion.
- In order to have provided a more fruitful discussion on CMM it would have been beneficial to provide read-ahead materials for participants to have reviewed ahead of the workshop. In addition, having the CMM graphic available in the binder packets and on the screen would have been a good visual while walking through this session.
- Could develop a one-page case study that provides examples of states that are executing their WRTM at different levels of maturity (Battelle has a task to develop CMM and will present this idea forward)
## Appendix A: Workshop Agenda

**Wednesday, September 25, DAY 1**

### Session 1-1
**Opening Session and WRTM Overview**
- **Moderator** – Roemer Alfelor (FHWA)
- **8:00-8:20** Welcome and Introductions
  - Roemer Alfelor
- **8:20-8:30** FHWA/USDOT Welcome Remarks
  - Mark Kehrli (FHWA)
- **8:30-8:40** Utah DOT Welcome Remarks
  - Shane Marshall (Utah DOT)
- **8:40-8:50** FHWA WRTM Program Overview
  - Roemer Alfelor
- **8:50-9:00** Meeting Objectives, Agenda, and Logistics
  - Deepak Gopalakrishna (Battelle)

### Session 1-2
**A Tough Year: Real-World Experiences and Applications of WRTM**
- **Moderator** – Laura Meitz (Battelle)
- **9:00-9:15** Winter Storms in Mid-West - Kansas City
  - Nancy Powell (MoDOT)
- **9:15-9:30** Flooding - Hurricane Sandy, New Jersey
  - Jim Hadden (NJDOT)
- **9:30-9:45** Fog/Low Visibility Crashes in Virginia
  - Tim Martin (VDOT)
- **9:45-10:15** Moderated Discussion
  - Laura Meitz

#### 10:15-10:30 BREAK

### Session 1-3
**Weather-Responsive Citizen Reporting and Social Networking**
- **Moderator** – Fred Kitchener (McFarland Management, LLC)
- **10:30-10:40** Wyoming’s Citizen Reporting Program
  - Vince Garcia (WyDOT)
- **10:40-10:55** Utah’s Citizen Assisted Reporting System
  - Lisa Miller (UDOT), Leigh Sturges (Narwhal Group)
- **10:55-11:05** Idaho’s Citizen Reporting Program
  - Tony Ernest (ITD)
- **11:05-11:15** North Carolina DOT’s Social Networking System for Weather
  - Lisa Schell (NCDOT)
- **11:15-11:30** Moderated Discussion
  - Fred Kitchener

#### 11:30-12:30 LUNCH (on own)

### Session 1-4
**Weather-Responsive Active Traffic Management and Signal Control**
- **Moderator** – Deepak Gopalakrishna
- **12:30-12:45** Weather and ATM in Oregon
  - Galen McGill (ODOT)
- **12:45-1:00** Weather-Responsive Ramp Metering in Washington State
  - Vinh Dang (WSDOT)
- **1:00-1:15** Weather-Responsive Traffic Signal Management in Utah
  - Mark Taylor (UDOT)
- **1:15-2:00** Moderated Discussion
  - Deepak Gopalakrishna

#### 2:00-2:15 BREAK

### Session 1-5
**Data Resources for Traffic Managers**
- **Moderator** – Fred Kitchener
- **2:15-2:30** Weather Information for Traffic Management
  - Ralph Patterson (Narwhal Group)
- **2:30-2:45** Traffic Data Resources for WRTM
  - Deepak Gopalakrishna
- **2:45-3:00** Moderated Discussion
  - Fred Kitchener
<table>
<thead>
<tr>
<th>Session 1-6</th>
<th>Weather Responsive Traveler Information Systems</th>
<th>Deepak Gopalakrishna</th>
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<tbody>
<tr>
<td>3:00-3:15</td>
<td>Road Condition Reporting - Developments and Challenges</td>
<td>Dave Huft (SDDOT)</td>
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<td>3:15-3:30</td>
<td>Commercial Travel and the Role of Road Weather Information</td>
<td>Vince Garcia (WyDOT)</td>
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<td>3:30-3:45</td>
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<tr>
<th>Session 1-7</th>
<th>Facilitated Group Discussion – Improving Organizational Capabilities for WRTM</th>
<th>Roemer Alfelor and Deepak Gopalakrishna</th>
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<td>3:45-4:30</td>
<td>Moderated Discussion</td>
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END OF DAY 1

THURSDAY, SEPTEMBER 26, DAY 2

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<tr>
<th>Session 2-1</th>
<th>Day 2 Opening Session</th>
<th>Roemer Alfelor</th>
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<tbody>
<tr>
<td>8:00-8:10</td>
<td>Review of Day 1 and Preview of Day 2 Activities</td>
<td>Roemer Alfelor</td>
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<tr>
<th>Session 2-2</th>
<th>WRTM and Connected Vehicles</th>
<th>Roland Stanger (FHWA)</th>
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<tr>
<td>8:10-8:20</td>
<td>RWMP Activities on Connected Vehicles Research Program</td>
<td>Roemer Alfelor</td>
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<td>8:20-8:30</td>
<td>Integrated Mobile Observations Project</td>
<td>Sheldon Drobot (NCAR)</td>
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<td>8:30-8:45</td>
<td>Using Mobile Data in WRTM, a State’s Perspective: Michigan DOT</td>
<td>Steve Cook (MDOT)</td>
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<td>8:45-9:00</td>
<td>Moderated Discussion</td>
<td>Roland Stanger (FHWA)</td>
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<tr>
<th>Session 2-3</th>
<th>WRTM Analysis, Modeling and Performance Evaluation</th>
<th>Roemer Alfelor</th>
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<tr>
<td>9:00-9:15</td>
<td>Recent Advances in WRTM Analysis, Modeling and Performance Evaluation</td>
<td>Roemer Alfelor</td>
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<tr>
<td>9:30-9:45</td>
<td>Moderated Discussion</td>
<td>Roemer Alfelor</td>
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9:45-10:00 BREAK

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<tr>
<th>Session 2-4</th>
<th>Facilitated Group Discussion - Integrating Maintenance and Traffic Operations during Weather Events</th>
<th>Fred Kitchener and Deepak Gopalakrishna</th>
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<td>10:00-11:00</td>
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<tr>
<th>Session 2-5</th>
<th>Facilitated Group Discussion – Future WRTM Program Activities and Workshop Wrap-Up</th>
<th>Roemer Alfelor and Deepak Gopalakrishna</th>
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<tr>
<td>11:00-12:00</td>
<td>Moderated Discussion</td>
<td>Roemer Alfelor and Deepak Gopalakrishna</td>
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END OF DAY 2
## Appendix B: Participant List

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<tr>
<th>State</th>
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<td>Stickel</td>
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<td>Ernest</td>
<td>Idaho Transportation Department</td>
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