INTERSTATE 80

Winter Operations Coalition

Kick-off Workshop Packet

JANUARY 26-27, 2010 RENO, NEVADA

PREPARED BY

Kimley-Horn and Associates, Inc.

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TRAVEL INFORMATION

EXPENSE INFORMATION

Conference attendance **includes** the following and has been organized as a group (no individual purchases necessary):

- Flight costs to/from Reno (if necessary) – consultant will arrange flight
- Hotel nights
- Food during conference
  - Tuesday lunch, afternoon snack, and dinner
  - Wednesday breakfast, morning snack, and lunch
- Internet in room (if necessary)
- Transportation to/from Reno airport – Circus Circus shuttle

Expenses that can be submitted for reimbursement after conference include:

- Airport parking costs
- Mileage (if used)

Hotel rooms, conference meals, and in-room internet are included with your attendance. Conference attendance **does not include the following, and they will not be reimbursed**:

- Room service
- Movies
- In-room telephone costs
- Business center costs
- Restaurant or bar costs
- Meals prior to or after scheduled conference times (i.e. if flying in the Monday rather than Tuesday)
- Vehicle rentals
- Taxi fares
- Other incidentals purchased individually

Hotel Information

Circus Circus Reno

500 North Sierra Street

Reno, Nevada 89503

1-800-648-5010

Meeting Space Location

Workshop activities will take place in Mandalay 1, Mandalay 2, and Mandalay 3 in the lower level of the Circus Circus Convention Center. Meeting room information will be available on Channel 22 in your room, as well as reader boards throughout the property.

A Circus Circus Property Map is attached for your use.

Check-In/Check-Out (If Applicable)

Check-In Time: 3:00 PM

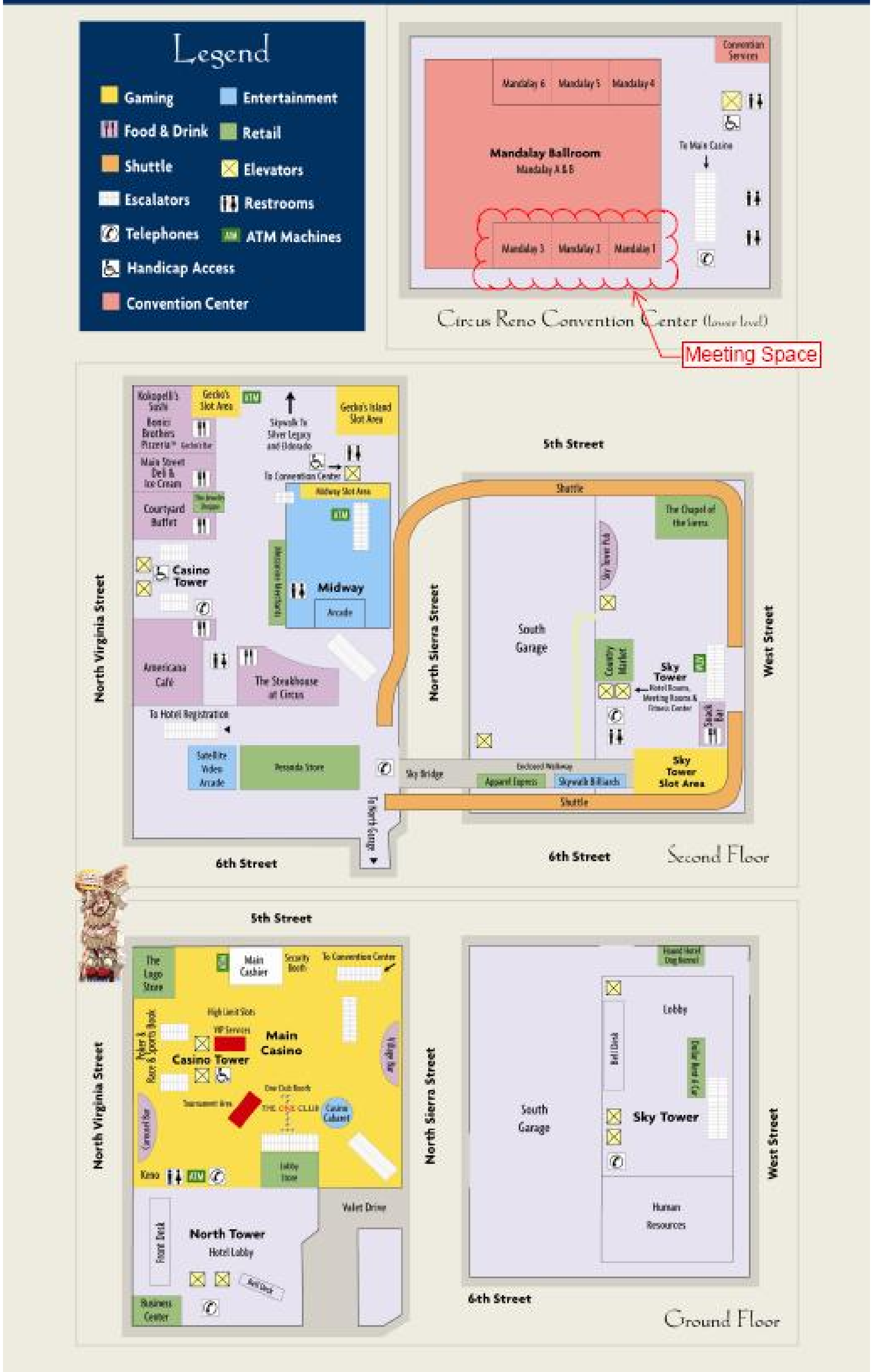
Those staying at Circus Circus who are covered by the project will be required to present a credit card at time of check-in to cover any additional incidental room charges over and above Internet. The rooming list as provided to Circus Circus on January 7, 2010 is attached. If you have any changes, please contact:

Molly O'Brien
702-862-3636 Office
702-806-2750 Cell
molly.obrien@kimley-horn.com

Check-Out Time: 12:00 Noon

It is recommended that you check out before the Workshop starts on Wednesday, January 27, 2010.

Circus Circus Property Map



IF DRIVING TO THE WORKSHOP

Directions to Circus Circus

From Sacramento, CA/I-80 East:

- Take I-80 East to Virginia Street Exit
- Turn right onto Sierra Street
- Turn left past Sixth Street intersection into Circus Circus Reno Valet and Registration Entrance or into the Self Park Entrance

From Susanville, CA/Highway 395 South:

- Take Highway 395 South to I-80
- Take I-80 West Exit
- Exit at Virginia Street
- Turn left onto Sierra Street, third intersection on the off ramp
- Turn left last Sixth Street intersection into Circus Circus Reno Valet and Registration Entrance or into the Self Park Entrance

From Carson City, NV/Highway 395 North:

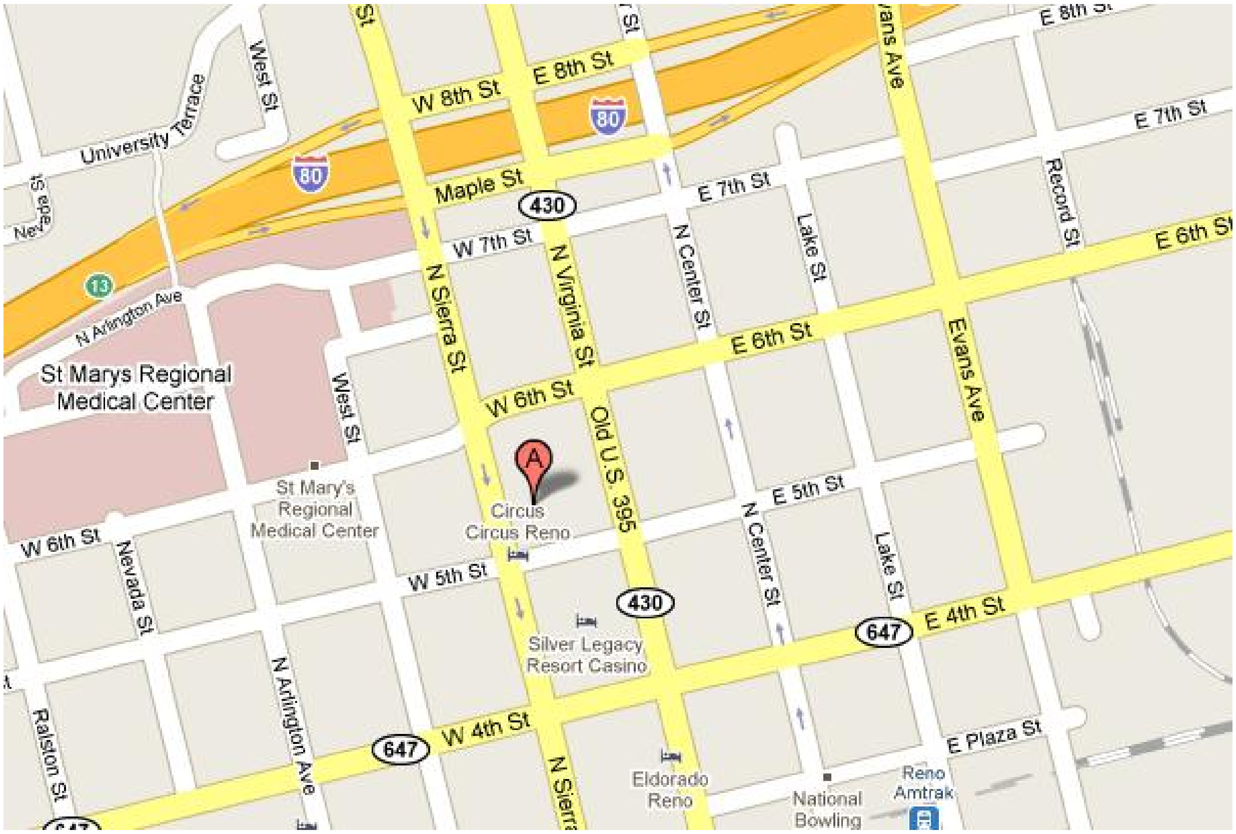
- Take Highway 395 North to I-80
- Take I-80 West Exit
- Exit at Virginia Street
- Turn left onto Sierra Street, third intersection on the off ramp
- Turn left past Sixth Street intersection into Circus Circus Reno Valet and Registration Entrance or into the Self Park Entrance

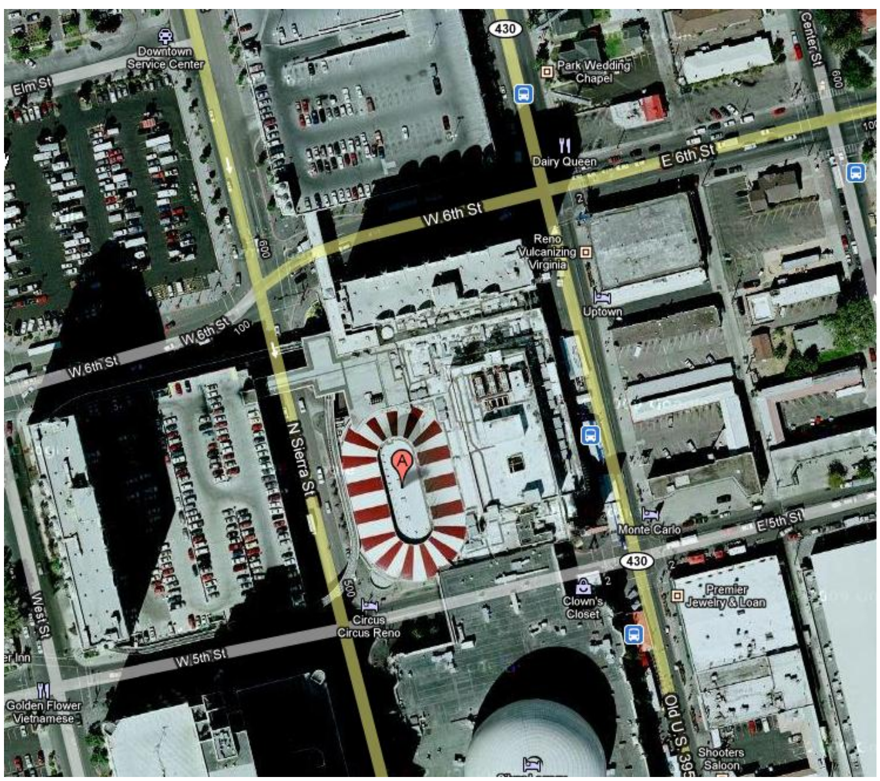
From Fernley, NV/I-80 West:

- Take I-80 West to the Virginia Street Exit
- Turn left onto Sierra Street, third intersection on the off ramp
- Turn left past Sixth Street intersection into Circus Circus Reno Valet and Registration Entrance or into the Self Park Entrance

Parking at Circus Circus

- **Self parking** at Circus Circus is free.
- **Valet parking** is free, but you will have to tip the valet driver. If you choose to valet park, tips will NOT be reimbursed.


E 8th St
W 8th St
E 8th St
80
University Terrace
West St
Maple St
430
E 7th St
W 7th St
N Virginia St
N Center St
Lake St
Evans Ave
Record St
E 7th St
E 6th St
N Arlington Ave
13
St Marys Regional
Medical Center
N Sierra St
West St
E 6th St
W 6th St
Old U.S. 395
St Mary's
Regional
Medical Center
Circus
Circus Reno
E 5th St
W 6th St
Nevada St
W 5th St
N Center St
Lake St
Silver Legacy
Resort Casino
647
E 4th St
N Arlington Ave
Ralston St
W 4th St
647
N Sierra
Eldorado
Reno
E Plaza St
National
Bowling
Reno
Amtrak


430
Downtown
Service Center
Elm St
Park Wedding
Chapel
Center St
Dairy Queen
E 6th St
W 6th St
Reno
Vulcanizing
Virginia
Uptown
W 6th St
W 6th St
N Sierra St
Monte Carlo
E 5th St
430
Premier
Jewelry & Loan
Clown's
Closet
Circus
Circus Reno
West St
W 5th St
Golden Flower
Vietnamese
Old U.S. 395
Shooters
Saloon

IF FLYING TO THE WORKSHOP

Transportation to/from Circus Circus from the Airport

Circus Circus has a free airport shuttle. You will NOT be reimbursed for taxis or rental cars.

To Circus Circus from the Airport:

- The first shuttle leaves the airport at 5:15 AM.
- The last shuttle leaves the airport at 12:15 AM.
- Shuttles run from the airport every half hour on the quarter hour.

To the Airport from Circus Circus:

- The first shuttle leaves the hotel at 5:00 AM.
- The last shuttle leaves the hotel at 12:00 midnight.
- Shuttles run from the hotel every half hour on the hour and half hour.

Flight Information

If your flight was booked by Kimley-Horn, it is attached. You should have already received a copy of your itinerary at time of booking.

TAB 3 – WORKSHOP

WORKSHOP

I-80 Winter Operations Coalition
Kick-Off Meeting Agenda
Circus Circus Hotel - Reno, NV
January 26-27, 2010

Day 1 – Tuesday, January 26

Noon – 1:00 PM	**Mandalay 3**	**Informal Lunch/Attendee Arrival**	
1:00 – 1:15	**Mandalay 1**	**Welcome and Introductions** Brief intro to Coalition; Attendee Introductions	Bill Hoffman
1:15 – 1:30	**Mandalay 1**	**Workshop Objectives** Format of workshop Breakout sessions Outcomes – charters, priorities, next steps	Bill Hoffman Lisa Burgess
1:30 – 2:50	**Mandalay 1**	**State DOT Presentations** 15-20 minute presentations from each state on winter ops and maintenance, current systems, significant projects/programs – a 'what's happening' among the member states	Reps from each state
2:50 – 3:05	**Break**		
3:05 – 3:35	**Mandalay 1**	**Federal/National Initiatives and Perspectives** Update on current programs, major initiatives from the national level	Roemer Alfelor - FHWA
3:35 – 4:35	**Mandalay 1**	**Innovative Approaches** Innovative practices and programs for winter ops/maintenance with focus on technologies, freight, traveler info, multi-state coordination	Tony McClellan – Indiana DOT Denise Markow – New Hampshire DOT Tony Mouser – Northwest Weathernet
4:35 – 5:15	**Mandalay 1**	**Challenges Facing the I-80 Corridor** Initial list of critical issues, potential focus areas	Group Discussion
5:15 – 5:25	**Mandalay 1**	**Day 1 Wrap Up**	Lisa Burgess Bill Hoffman
5:25 – 5:30	**Mandalay 1**	**Format and Charge for Day 2**	Lisa Burgess
6:00 – 8:00	**Mandalay 3**	**Dinner**	

Day 2 – Wednesday, January 27

7:00 – 7:30 AM	**Mandalay 3**	**Breakfast ***	
7:30 – 7:45	**Mandalay 1**	**Welcome and Overview of Day 2**	Lisa Burgess
7:45 – 9:15	**Mandalay 1** **Mandalay 2**	**Breakout Sessions** TMC/Operations Breakout Group Maintenance Breakout Group	KHA facilitate and scribe breakout sessions
9:15 – 10:00	**Mandalay 1**	**Breakout Session Reports**	Rep from each breakout group
10:00 – 10:15	**Break**		
10:15 – 11:15	**Mandalay 1**	**Prioritizing I-80 Corridor Needs/Issues** Group discussion on high priority needs, potential actions, where coalition approach could help advance key initiatives Low hanging fruit Longer-term strategic needs	Lisa Burgess Bill Hoffman
11:15 – 11:45	**Mandalay 1**	**Multi-State Coalition Feature/Case Study** Presentation from an existing multi-state group on coalition organization, approach to projects, funding, lessons learned What can I-80 Coalition apply to get off to a good start?	Bill Legg – WSDOT (Representative from North/West Passage)
11:45 – 12:45 PM	**Mandalay 3**	**Lunch**	
12:45 – 2:30	**Mandalay 1**	**Organizing For Success** Moving the I-80 Coalition Forward Governance Structure Coalition Communications Task Forces, Champions Strategic Plan	Lisa Burgess Bill Hoffman Group Discussion
2:30 – 3:00	**Mandalay 1**	**Wrap Up and Next Steps**	Lisa Burgess
3:00	**Attendees Depart ****		

* *For those attendees staying at Circus Circus, it is recommended that you check out prior to breakfast.*

***End time on day 2 will be flexible to accommodate travel schedules*

DRESS CODE

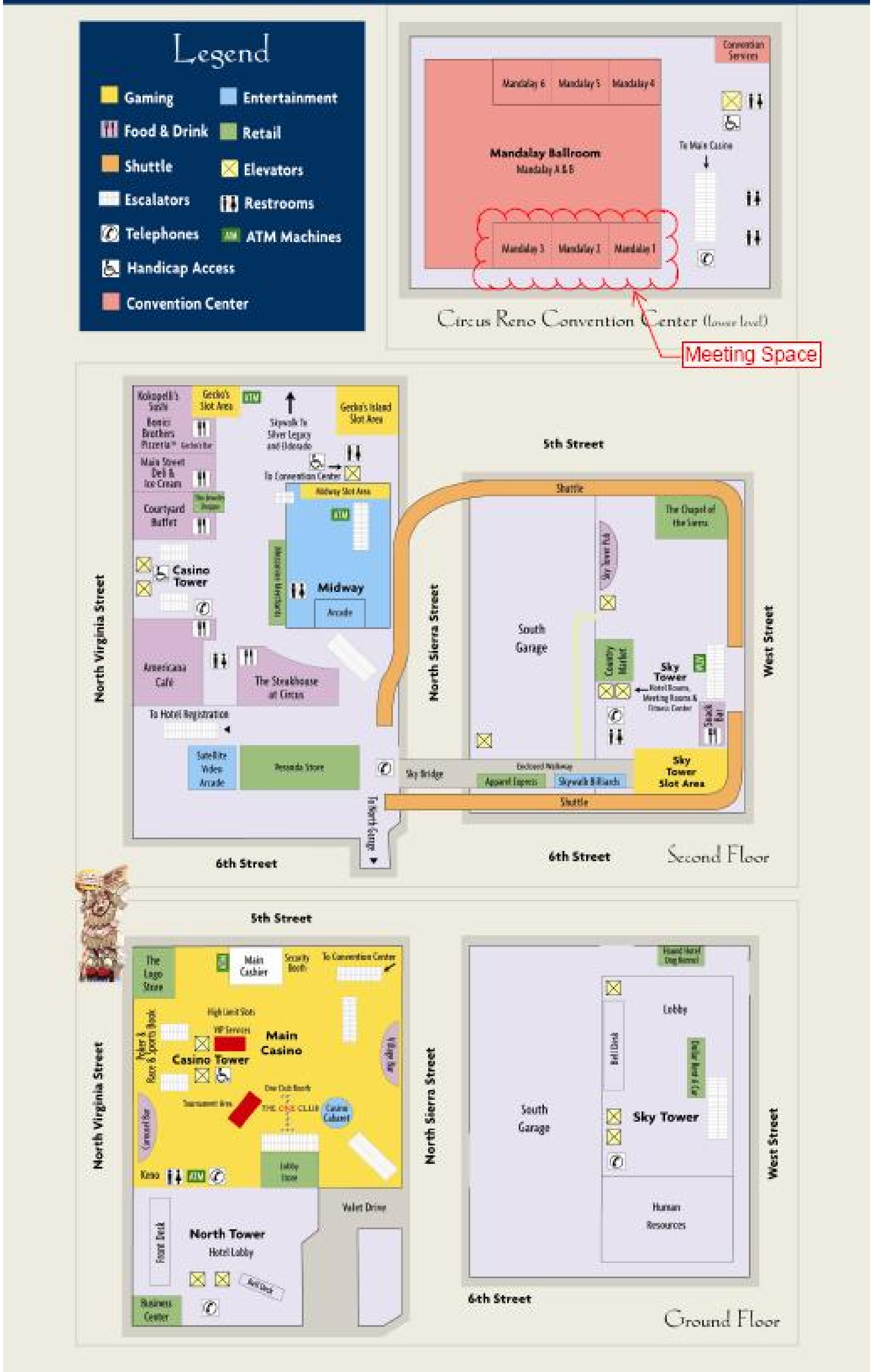
The dress code for the Workshop is Business Casual.

MEETING SPACE LOCATION

Workshop activities will take place in Mandalay 1, Mandalay 2, and Mandalay 3 in the lower level of the Circus Circus Convention Center. Meeting room information will be available on Channel 22 in your room, as well as reader boards throughout the property.

A Circus Circus Property Map is attached for your use.

Circus Circus Property Map



WORKSHOP PRESENTATIONS

Will be provided at the Workshop.

NOTES

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TAB 4 – I-80 COALITION MATERIALS

SURVEY RESPONSES SUMMARY

Coalition Key Objectives Summary		
	Traffic management operations during winter conditions Truck parking during closures Limited alternate routing Not enough staffing to support operations sometimes when needed Need more road closure information and anditicpated road condition information	Efficient use of ITS device data and potentially shared use Use other resources to supplement data (NWS, Clarus, etc.) Mimic successful and unique strategies in partner states (i.e. Ecar, UDOT Meteorologist in TMC Better weather and database integration TMC integration and coordination

Survey Topics	Caltrans	NDOT	UDOT	WYDOT
Maintenance Procedures/ Coordination	Snow and ice control operations - plowing, sanding, anti-icing, traffic management operations Independent maintenance activities from traffic operations	Anti-icing Snowplowing Interdistrict DOT coordination In-district coordination (NHP, local sherriffs, local road depts, ski areas, RTCs, etc.) Coordination with UT, CA, OR, and ID 10-7 and 10-8 all personnel during snow and ice operations	Winter maintenance coordination takes place on the field level Interstate operations and traveler information at the TOC	Road closures Assistance in winter maintenance
Challenges	**Traffic management issues during snow removal operations** Keeping I-80 open during storems **Storage of trucks while roadway is closed** Communications between Kingvale Operations Center, CHP Truckee Dispatch and the Caltrans TMC	**Reduced budgets and staffing** **Caltrans I-80 closures create truck parking problems in Reno** Incident management Weather issues Resources such as construction issues	High winds Blowing snow Low bisibility **Gathering real time information (incidents) in the rural areas** Most of I-80 is not covered well by NWS radar sites	Extended periods of high winds **No routes close by that serve as good alternates** **Not enough staffing when alternate routes are needed**
Beneficial Information	When traffic is released in other states due to closures **Traffic issues, road closures, openings, traffic volumes**	Roadway conditions Any control requirement **Road closure information for Donner Summit and CA/NV** stateline and estimated opening times Chain control information Incident management issues/information	**Current and anticipated road closures and road conditions**	**Road closure information** Significant storm events that push traffic onto I-80 as detour
Technologies and Tools Needed	**Weather integration** GPS vehicle navigation systems	MDSS **RWIS** CCTV cameras 511 HARs Video feeds from Caltrans at the pass Predict time related road conditions for 12 to 24 hours in advance of the current time over the I-80 corridor area	**Deploying portable radar sites to get better real-time information**	Variable speed limits

SURVEY RESPONSES SUMMARY

Coalition Key Objectives Summary	Traffic management operations during winter conditions Truck parking during closures Limited alternate routing Not enough staffing to support operations sometimes when needed Need more road closure information and anditicpated road condition information	Efficient use of ITS device data and potentially shared use Use other resources to supplement data (NWS, Clarus, etc.) Mimic successful and unique strategies in partner states (i.e. Ecar, UDOT Meteorologist in TMC Better weather and database integration TMC integration and coordination

Survey Topics	Caltrans	NDOT	UDOT	WYDOT
Operational Devices	CCTV cameras Detection RWIS Fixed DMS Portable DMS Meterologix data Department of Water Resources **National Weather Service information**	CCTV cameras Detection RWIS Fixed DMS Portable DMS 511 Phone/Web Partner agency traveler information system (state police)	CCTV cameras Detection RWIS Fixed DMS Portable DMS 511 Phone/Web Partner agency traveler information system (state police)	CCTV cameras Detection RWIS Fixed DMS Portable DMS 511 Phone/Web Partner agency traveler information system (state police) **ECar to report road conditions to frequent travelers**
Data/ Information Available	Road condition and closure information including chain control Internal paging system for internal CHIN website HARs CMS boards	511 Phone/Web - use highway restriction reports to post chain controls, accident data, construction, etc. NNROC sends out text and email alerts (internally) DMS board system on I-80 HAR system Share RWIS through Clarus	Current incidents/restrictions on website and HAR Present and forecasted weather and road conditions from RWIS Camera images provided on website Limited shared CAD with partners Lots of phone call interactions for coordination	Road and weather conditions Travel restrictions and advisory conditions Roadway closures Web cam images RWIS atmospheric conditions Forecasts through 511 telephone system Some web cams are PTZ Have RWIS surface sensors and paid forecast services
Support Stations	4 maintenance stations	D3 - 4 maintenance stations		12 maintenance facilities in close proximity to I-80
Support Staff	140 in place during winter 45 on-call during winter	D2 - 10-15 for I-80 in Reno area D3 - 80 to 90+/- staff - 6 crews with I-80 responsibilities		113 staff Supplement staff with striping, guardrail, construction personnel and mechanics
Support Vehicles	135 winter maintenance vehicles	D2 - 15-20 +/- due to equipment breakdowns, retentions, etc. D3 - 80+/- winter maintenance vehicles		87 trucks with plows and spreaders 6 rotary blowers 5 motorgraders
Support Centers	**Kingvale Operations Center and a satellite operation center**	**D2 - Northern Nevada Regional Operations Center** **D3 - Elko Traffic Operation/Management Center**	**UDOT TMC at Salt Lake City**	**WYDOT TMC** **2009-10 is first full winter in statewide operation**
Other Programs or Initiatives to Consider	Vehicle location tracking (working on it) **Weather integration (working on it)** **Database integration**	**Better weather prediction and forecasting** Improve and upgrade snow and ice equipment More standardized road and weather condition reporting system for travelers **Databases for sharing information**	**511 Meteorologist position has been introduced to TOC** - single point of contact for all weather-related traveler information Initiated a Road Condition forecast page for I-80 in Utah	**Improving weather forecasting, especially road surface** Better understand all factors that contribute to increasted traffic at various times of the year

I-80 Coalition Survey

1. Default Section

The purpose of this survey is to document existing practices within the Coalition states as well as determine common areas of interest between the stakeholders. Information gathered from this survey will provide input to the I-80 Winter Operations Coalition's development, focus areas, and discussion topics at the workshop to be help in January 2010. Thank you in advance for your valuable input.

* 1. Please provide the following information:

Name:

Agency:

Address:

Address 2:

City/Town:

State:

ZIP Code:

Email Address:

Phone Number:

* 2. What topics would you like to see covered at the I-80 Coalition Conference in January, 2010?

	Not Important	Somewhat Important	Important	Very Important	Extremely Important
Traveler Information Services	○	○	○	○	○
Weather Information	○	○	○	○	○
Work Zone Management/Construction Coordination	○	○	○	○	○
Freight and Goods Movement	○	○	○	○	○
Information Systems	○	○	○	○	○
Maintenance	○	○	○	○	○
Operations	○	○	○	○	○

Other (please specify)

* 3. What maintenance procedures/coordination are typically performed during winter conditions in your state?

* 4. What challenges do agencies in your state face during winter conditions on I-80?

I-80 Coalition Survey

* 5. What information is beneficial to know for winter activities happening in neighboring states with whom you share borders with?

* 6. What maintenance or operations technologies and tools have you researched on a local, state, or federal level that would be of interest to include in the discussions at the workshop? What would be beneficial for your state to look into for potential use during winter maintenance or operations activities?

* 7. What operational devices does your state use during winter months to monitor road conditions, inform travelers, and respond to changing conditions?

- [ ] Cameras
- [ ] Detection
- [ ] RWIS
- [ ] Fixed DMS
- [ ] Portable DMS
- [ ] 511 Phone/Web
- [ ] Partner agency traveler information system (such as state police)
- [ ] None
- [ ] Other (please specify)

* 8. What data/information is available in your state related to road/maintenance conditions and incidents? How do you currently share that data internally to agency departments and externally via traveler information services to the public?

I-80 Coalition Survey

* 9. What level of support staff and facilities are available to support winter activities in your state?

Proximity of maintenance facilities to I-80

Number of staff

Winter maintenance vehicles

Traffic management operations centers

Other

* 10. Briefly describe some current programs or initiatives that would benefit from a sustained I-80 Winter Operations Coalition (vehicle location tracking, RWIS locations, databases, websites, new technologies, etc.)?

I-80 Winter Operations Coalition
Draft Charter

Element	Definition	Description/Focus
Coalition Overview	Description of the Coalition	Interstate 80 is a major east-west interstate corridor through the states of California, Nevada, Utah and Wyoming, and is a major economic freight and traveler corridor which can better service the public through improved and coordinated maintenance and traveler information services. Integration and continuity of Winter Maintenance Operations across the United States is needed to provide consistent traveler information and similar levels of service to achieve a higher degree of boundary transparency and improved mobility, as seen by the traveling public. I-80 states have initiated a single strategic planning effort to reach consensus on how best to link operational processes and data to maximize winter mobility in their I-80 corridor.
Charter Purpose	Sets boundaries, constraints and requirements	The I-80 Winter Operations Coalition must work within this charter and structure and will be focused on winter operations and coordination across state boundaries along I-80. The purpose of this Charter document is to obtain sponsor approval of the project including the vision, goals, roles and responsibilities, and business practices of the I-80 Winter Operations Coalition.
Goals and Objectives	Goals and objectives for the Coalition	A set of Coalition goals and objectives have been established to guide the development of this Charter. The I-80 Winter Operations Coalition objectives are: • Establish and maintain a forum for regular communications and ongoing collaboration and planning for I-80 winter operations; • Establish institutional structure for coordinating operations, including leveraging existing state programs; • Establish existing capabilities and near-term enhancements to identify specific continuity issues; and • Research innovative practices from other areas of the country facing similar challenges to potentially apply these practices within the I-80 corridor.
Stakeholder Involvement	Types of agencies and companies involved	Stakeholders were initially selected to represent the champions of the Coalition from each state in the most impacted areas of I-80 operations during the winter seasons. Stakeholders may be asked to participate in specific committees or focus groups based on the priorities established during the first Coalition Conference. This may include participation in Coalition activities, projects and research outside of formal meetings and conferences and could also include participation and presence at the Coalition meetings. Initial key partners are envisioned to include: • NDOT Headquarters Operations and Maintenance • NDOT District 2 and 3 Operations and Maintenance • Nevada Highway Patrol • Caltrans District Operations and Maintenance (Kingvale) • California Highway Patrol • Utah DOT Operations and Maintenance • Wyoming DOT Operations and Maintenance Additional stakeholders may be asked to participate within certain Coalition projects or activities (to be determined by Coalition members, and on a project-by-project basis). Additional stakeholders could include: • State Highway Patrol • Local Transportation Management Centers • District Level Operations within each state DOT • Public Information Office/Communications • Regional Transportation Agencies • University Transportation Research Centers • Local Law Enforcement (as needed for I-80 purposes) • Tow Truck Companies • Freight Companies • DOT Information Technology

I-80 Winter Operations Coalition
Draft Charter

<table>
<tr><th>Element</th><th>Definition</th><th>Description/Focus</th></tr>
<tr><td>Membership Voting</td><td>Description of roles in voting for Coalition activities</td><td>Each membership agency is also allowed one vote on the Executive Committee to make key decisions on Coalition activities moving forward.

Members that do not choose a voting seat on the Executive Committee are still able and encouraged to participate in the TMC/Operations Committee, Maintenance Committee and Coalition Working Groups to ensure a broad base of knowledge and perspectives.

All votes may be case by voice or by a show of hands during Coalition meetings. Any voting member may request a roll call vote during meetings. For decision-making between meetings, voting by telephone, facsimile, online survey, or e-mail polling may be undertaken when deemed suitable by the Executive Committee or Committee Chairperson.</td></tr>
<tr><td>New Member Process</td><td>Method for bringing on new members</td><td>Agencies and companies wishing to participate in the Coalition must request to become a member via written communication. Membership requires the approval of the I-80 Winter Operations Coalition Executive Committee. As the Coalition expands, additional membership levels may be added after a majority vote of the Executive Committee.</td></tr>
<tr><td>Executive Committee Structure and Roles</td><td>Description of Executive Committee and roles</td><td>It is recommended that the Executive Committee consists of one member from each coalition partner agency. The Executive Committee will select a Committee Chair-Person and Vice Chair-Person. It is recommended that the Executive Committee meet on a quarterly basis to review the goals and objectives of the Coalition. Frequency of meetings will be determined at the January workshop. Responsibilities of the Executive Committee include, but are not limited to:
Developing long term goals and objectives of the Coalition
Empowered to make a decision if the group needs to move forward and cannot agree
If there are funding or other resource needs, change in direction or focus, the chair will raise the issues with both the TMC/Operations and Maintenance Committees
Prioritize projects and activities for Coalition
Researching and applying for funding
Developing annual work plan for the Coalition
Developing the Coalition long-range work plan and maintaining the Strategic Plan
Provide input and approve of the Coalition Strategic Plan
Reviewing and approving membership requests
Developing and managing the Coalition budgets
Develop agenda and materials for Annual Coalition Conference
Updating the organizational structure, as needed
Reviewing the reports and findings provided by the TMC/Operations Committee, Maintenance Committee, and (future) Coalition Working Groups
Represent Coalition at national level activities, including AASHTO meetings, ITS America, Rural ITS Conference, and others. Liaise with other Coalitions or regional activities</td></tr>
</table>

I-80 Winter Operations Coalition
Draft Charter

Element	Definition	Description/Focus
TMC/ Operations Committee and Maintenance Committee Structure and Roles	Description of TMC/Operations Committee and Maintenance Committee and roles	The TMC/Operations Committee is focused on transportation issues and operations of the corridor and coordination with neighboring states TMCs. The Maintenance Committee is focused on winter maintenance activities and issues that are experienced along the corridor during winter months and coordination efforts that could streamline or manage those activities more efficiently. It is proposed that these Committees meet once a year during the Annual Coalition Conference with more frequent teleconferences, webinars, videoconferences, or other communication method as needed; frequency of meetings/discussions will be agreed upon by the Committees. Each Committee will select a chair person who will be responsible for coordinating activities and communications of that committee, reporting committee activities to the Executive Committee. Potential responsibilities of these Committees include: • Providing input to short and long term goals of the Coalition, including project ideas, operational enhancements, and establishing processes for improving coordination on operations and maintenance activities; • Implement and oversee projects and processes, and report on effectiveness or recommended enhancements; • Provide input to the Coalition Strategic Plan
Coalition Working Groups Structure and Roles	Description of Working Groups and roles	These groups are intended to include participation from selected individuals from each member agency focused on a specific topic area of interest. Initial Working Groups suggested for the Coalition include Weather Management, Freight/Goods Movement, and Traveler Information. Working Groups may be added as membership increases, focus areas are introduced, or there is need to split an existing Working Group into multiple topics. Responsibilities of these Working Groups include: • Develop projects • Prioritize projects within respective topics • Identify support needed to implement projects • Identify up-and-coming issues/trends As the Coalition becomes more established and active, there could be a need to establish more task-oriented Working Groups to tackle specific issues. Potential Working Groups could include: *Weather Management Working Group* Available weather information throughout the corridor, defining coordinated reporting of roadway conditions, research information technologies, and developing operations and management strategies for the Corridor. *Freight and Goods Movement Working Group* Problem areas and challenges for freight and goods movement throughout the corridor, coordination with private freight companies, sharing of information, and developing strategies to improve these problems. *Traveler Information Working Group* Types of information that is beneficial to the public, to freight, and to other agencies and investigating potential strategies for providing more comprehensive and real-time traveler information about the I-80 corridor road conditions.

<table>
<tr>
<td>Charter Change Control</td>
<td>Process for modifying Coalition charter or structure</td>
<td>As the I-80 Winter Operations Coalition matures, there are anticipated to be modifications to the structure or the organization such as:
• Increase in membership groups
• Addition/Removal of Coalition Working Groups
• Addition/Removal of Committees
• Modification of membership fees
If the need arises to amend the Charter, this Charter may be amended by a majority vote of the voting membership. If less than one-half of the voting membership is not present for the vote, the entire membership shall be polled.</td>
</tr>
</table>

Figure – California and Nevada Supporting Infrastructure

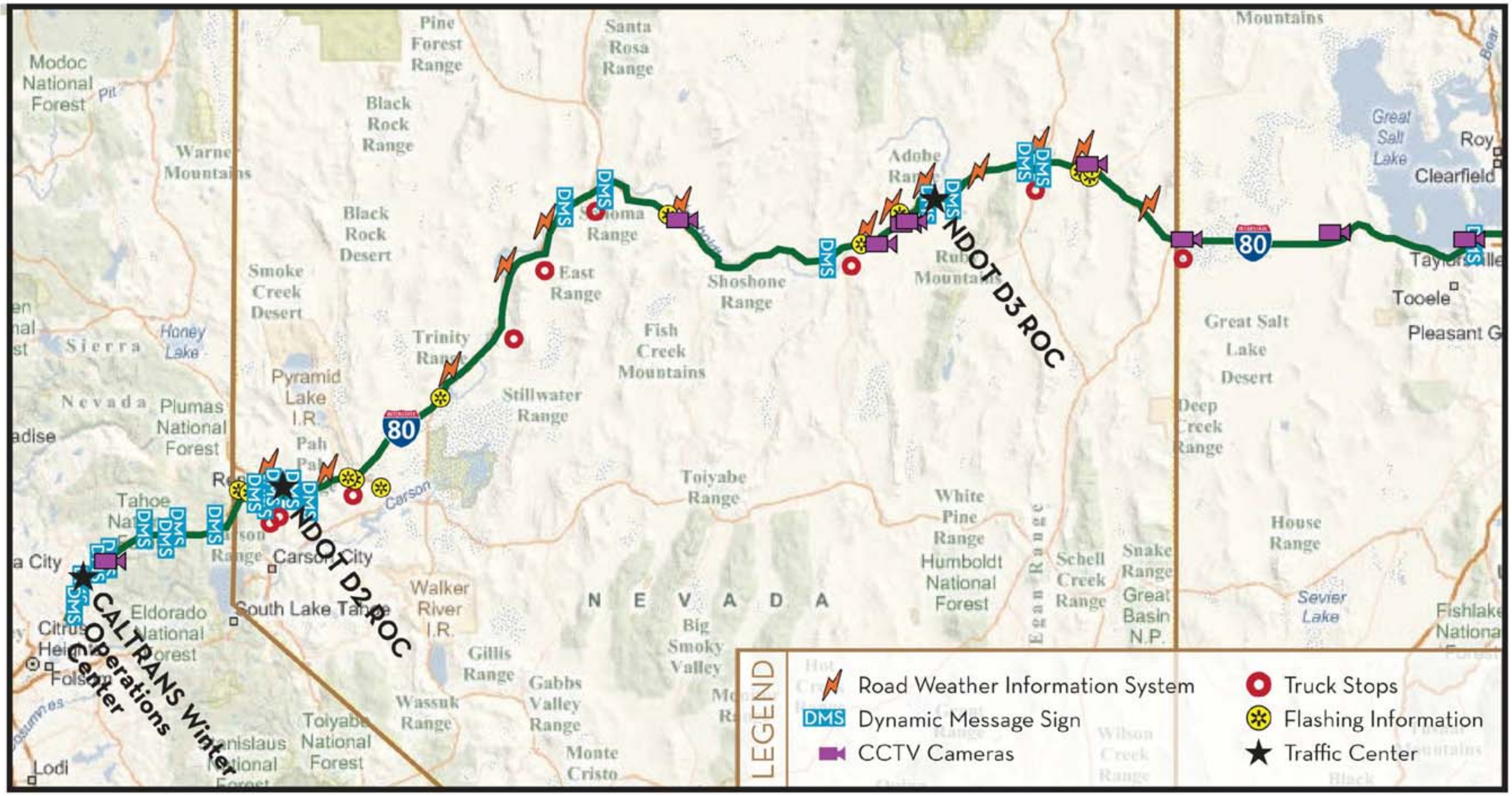
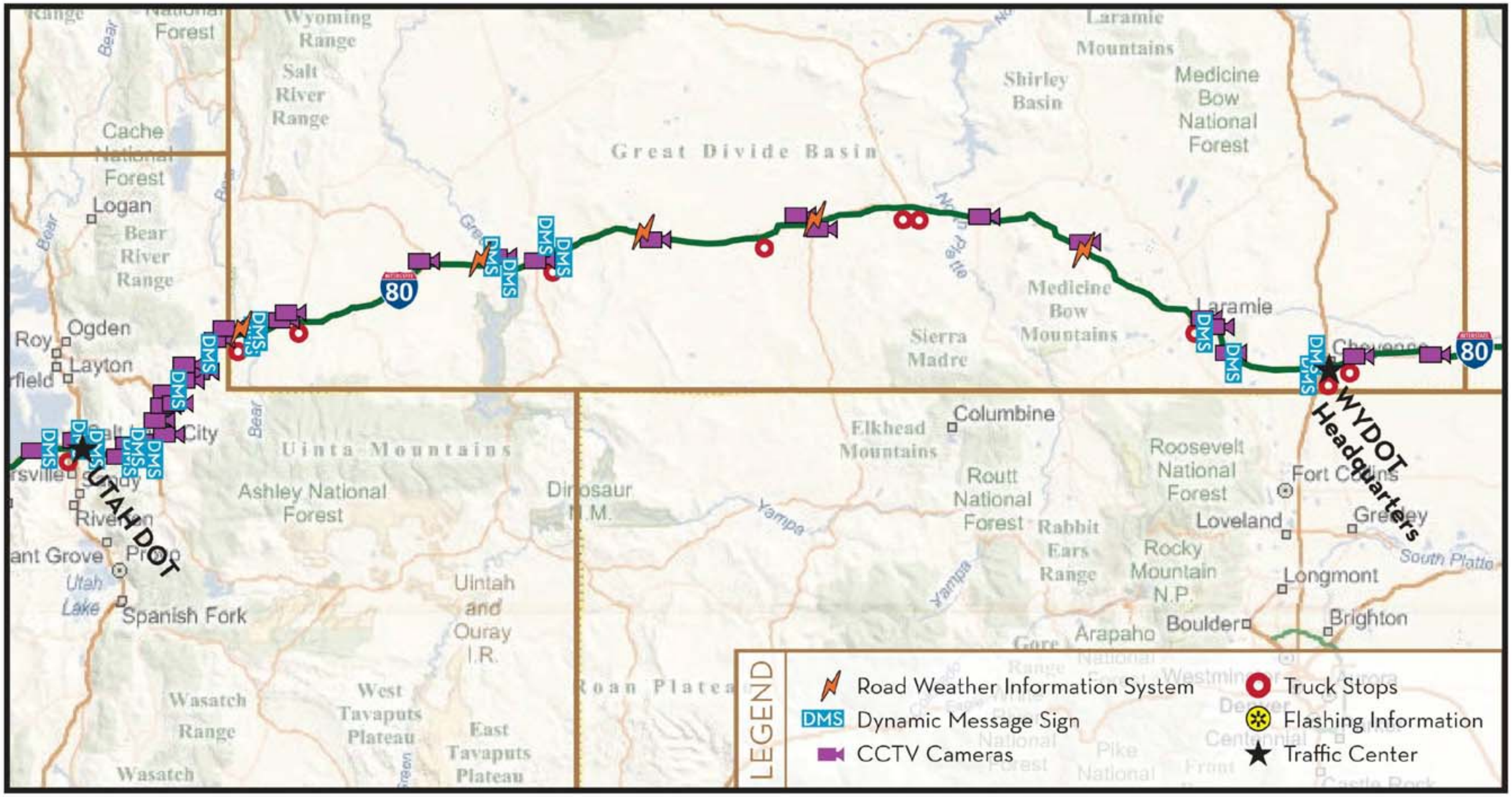


Figure – Utah and Wyoming Supporting Infrastructure



COALITION WEB SITE: www.i80coalition.com

INTERSTATE 80 WINTER OPERATIONS COALITION

Home | Coalition Overview | Member Agencies | Committees | Upcoming Events | Coalition Products | Links | Contacts

Corridor Overview

Interstate 80 is a major east-west interstate corridor through the states of California, Nevada, Utah and Wyoming, and is a major economic freight and traveler corridor which can better service the public through improved and coordinated maintenance and traveler information services. Integration and continuity of Winter Maintenance Operations across the United States is needed to provide consistent traveler information and similar levels of service to achieve a higher degree of boundary transparency and improved mobility, as seen by the traveling public. These four states have initiated a single strategic planning effort to reach consensus on how best to link operational processes and data to maximize winter mobility in their I-80 corridor.

Coalition Objectives

1. Establish institutional structure for coordinating operations on I-80 in the western states.
2. Aggregate weather conditions information from multiple sources.
3. Identify traffic data collection capabilities and share information with other agencies.
4. Establish existing capabilities and near-term enhancements to identify specific continuity issues.
5. Research innovative practices from other areas of the country facing similar challenges.

Partners in the News

- UDOT: Stripes Could Be De-icer
  December 2009
- Caltrans Geared Up For Winter
  November 2009
- UDOT Turns to Innovative Technology to Prepare for Winter Snow
  November 2009
- WYDOT Shows Balance With Road Closures
  July 2009
- Road Closures Are On The Rise
  June 2009

Our Purpose

To provide better and more comprehensive I-80 corridor conditions information to both transportation agencies and to travelers.

Build on existing multi-state coordination efforts on I-80 and expand to include general road conditions information, consistent corridor-wide traveler information, proactive traffic management strategies, coordinated maintenance operations and potentially shared use of infrastructure near state boundaries.

Leverage state resources and tools to implement innovative solutions for winter operations as well as day-to-day corridor management.

Our Partners

NEVADA DOT

UDOT CONNECTING COMMUNITIES

Caltrans

WYDOT TRANSPORTATION SYSTEMS PLANNING

Nevada Department of Transportation | 1263 South Stewart Street | Carson City, Nevada, 89712

TAB 5 – BACKGROUND INFORMATION

RELEVANT COALITIONS OVERVIEW

1. INTRODUCTION

The purpose of this document is to provide an overview of other established and successful multi-state transportation coalitions. This document focuses on when and why the coalition was formed, how the coalition is organized, funding, projects and benefits of the coalition. This document also includes information on the Transportation Pooled Fund (TPF) program and lessons learned from other coalitions. The I-80 Winter Operations partner states can use this document as a reference to help them as they form their Coalition.

2. DETAILS OF RELEVANT COALITIONS

The following sections outline relevant information relating to other established successful multi-state transportation coalitions. Emphasis is placed on when the coalition was formed, how it is organized, funding, projects, and benefits/outcomes.

2.1 I-95 Corridor Coalition

http://www.i95coalition.org

The I-95 Corridor Coalition began in the early 1990s when transportation officials from several states met informally to address transportation issues. In 1993, the I-95 Corridor Coalition was formally established with the goals of enhancing transportation mobility, safety, and efficiency in the eastern United States. When the Coalition began, the main focus was on ITS and roadway transportation issues, but has since expanded to cover all modes of transportation within the corridor. The I-95 Corridor Coalition currently includes transportation agencies, toll authorities, transit and rail authorities, port authorities, rail, state police and law enforcement.

The I-95 Corridor Coalition provides a forum to address transportation management and traffic operations issues of key interest to the agencies and transportation within the corridor. Over the past 25+ years, the I-95 Corridor Coalition has become a model for multi-state/jurisdictional interagency coordination and coordination.

The I-95 Corridor Coalition stretches from Florida to Maine, and extends into Canada. The following states are involved in the I-95 Corridor Coalition:

- Connecticut
- Delaware
- Washington, D.C.
- Florida
- Georgia
- Maine
- Maryland
- Massachusetts
- New Hampshire
- New Jersey
- New York
- North Carolina
- Pennsylvania
- Rhode Island
- South Carolina
- Vermont
- Virginia

According to their website, the I-95 Corridor Coalition covers:

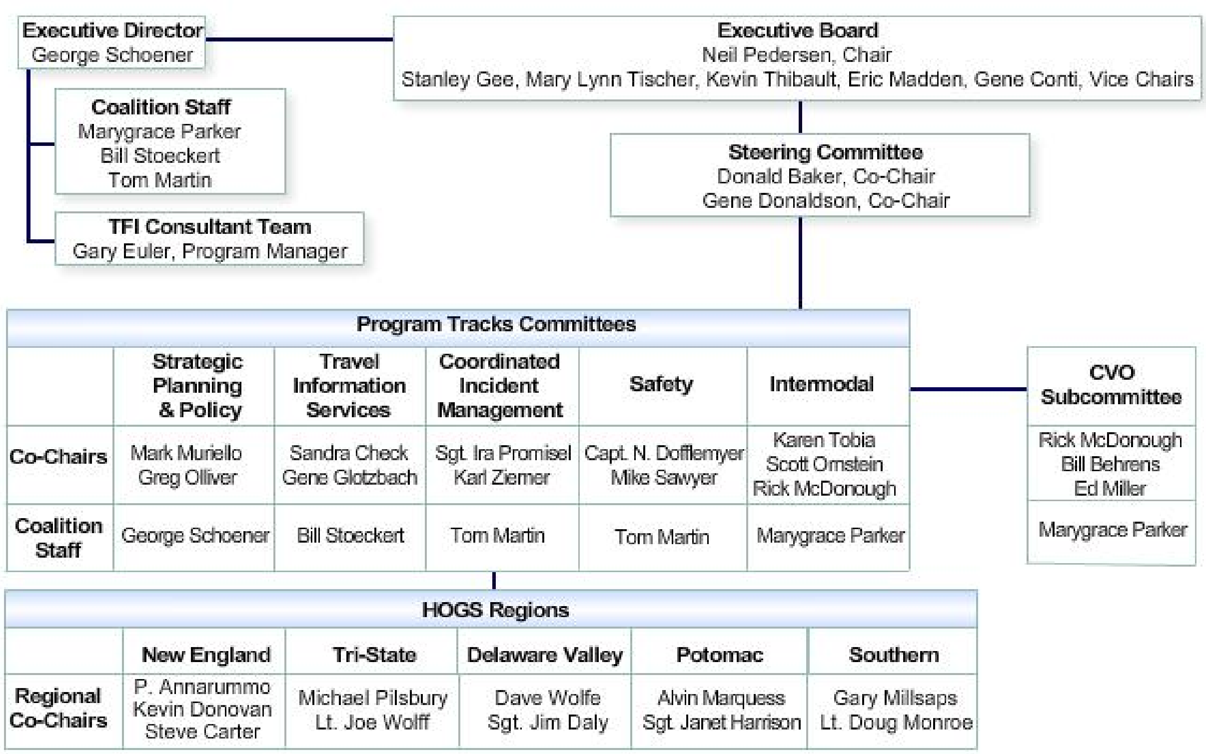
- 1,917 Miles of I-95
- 40,000 National Highway System Miles
- 22,000 Miles of Class 1 Rail Mileage
- 46 Major Seaports
- 103 Commercial Airports

2.1.1 Roles and Responsibilities

The Coalition does not have a formal set of By-Laws or guiding rules; however, the I-95 Corridor Coalition has adopted a number of procedures, policies, and guidelines to facilitate its operation. These guidelines are published in the *I-95 Corridor Coalition Procedural Guidelines* manual. The manual is updated on a regular basis as the organization evolves and changes. Topics covered in the manual include: organization, membership requirements, program development, project management, contract management, and other operating policies.

Figure 1 shows the organization of the I-95 Corridor Coalition. The I-95 Corridor Coalition is divided into different committees that focus on different areas areas and disciplines, such as travel information services, coordinated incident management, and safety. Projects are carried out at the committee level.

Figure 1 – I-95 Corridor Coalition Organization Structure



Source: www.i95coalition.org

2.1.2 Frequency of Meetings

The I-95 Corridor Coalition Executive Board meets twice a year in person (June and December). The other committees decide on an appropriate meeting schedule and/or meeting format. In general the committees meet once a year in person with teleconferences/webcasts throughout the remainder of the year.

2.1.1 Funding

The Coalition typically receives 80 percent of its funding from the Federal Government matches and 20 percent from the member agencies. Each year, the Coalition publishes a summary of match fund status along with the annual work plan. The following match fund policy is currently in effect for the Coalition:

- **Coalition Deployment and/or Integration Projects:** Member agencies and participants are responsible for the 20 percent "project specific" funding match. This match can be assembled from the private or public sector and must be from non-federally derived sources. The contribution can consist of money, equipment for the project, or personnel to complete the project.
- **General Support Activities:** Member agencies and participants can use "pooled" match credits to satisfy match requirements for administrative activities, training, studies, etc. Member agency projects can be use as "pooled" match credits if they are consistent with the Coalition's projects and activities. The match credits must be from non-federally derived sources and members cannot use the same projects or resources to match other federal funds for their agency.

2.1.2 Projects

Each year, the Executive Board creates a project guidance document and issues it to all Coalition Program Track Committees. The Track Committees, member agencies, staff and other sources outside the Coalition may submit project proposals. After all project proposals are received, the Coalition hosts a Policy and Strategic Planning Meeting where the different proposals are ranked in order of importance. The project list then goes to the Steering Committee for review. The projects recommended for funding are then passed on to the Executive Board for final approval. **Figure 2** shows detailed program planning cycle for the Coalition.

Figure 2 – I-95 Corridor Coalition Program Planning Cycle

Calendar Cycle	*Current Year Program Planning*
April/May	• Executive Board/Steering Committee issue guidance, setting broad program priorities
May	• Program Track Committees review goals and objectives, adding or changing as appropriate; develop new project ideas with brief scopes, and prioritize them within objectives; assess readiness of new projects, identify project managers and secure match commitments for agency deployment projects
October ↓	• Program Track Committees submit a comprehensive work plan request
October	• Program Track Committee requests are compiled and submitted to the Steering Committee for review.
November	• Steering Committee reviews all submissions and develops a recommended work plan for the Executive Board
December ↓	• Executive Board adopts a work plan for that year and develops direction for the next work plan cycle.
	• Final work plan letter is submitted to FHWA
January	• FHWA formally approves the work plan
January – April	• Coalition itemizes the budget by project sponsor and amounts, working with FHWA
	• FHWA begins the partnership agreement issuance, or interagency agreements if required for a specific project
April/May ↓	• Next year's program planning cycle begins

Source: I-95 Corridor Coalition Procedural Guidelines, July 2009

Since 1993, the Coalition has performed numerous projects relating to:

- Policy and Strategic Planning
- Travel Information Services
- Incident Management
- Intermodal Projects
- Commercial Vehicle Operations
- Electronic Payment Services
- Safety

Relevant projects underway or that have been completed by the I-95 Corridor Coalition include:

- Private sector data procurement. The I-95 Corridor Coalition initiated the first multi-state contract to procure speed/slow/incident data from the private sector (INRIX). 4,100 centerline miles are currently covered and includes the entire limited access road network in New Jersey, and the entire interstate systems for North Carolina and South Carolina.

- Development of a real-time information dissemination system for efficient use of public and private truck parking. The system is comprised of the following subsystems: data collection, data integration, and data dissemination/traveler information.
- SAFETRIP-21 is a $6.4 Million partnership between the USDOT and the I-95 Corridor Coalition to use advanced technology to provide real-time traveler information, improve safety, improve public transportation, and reduce gridlock on the I-95 corridor.
- Training opportunities on topics such as performance measures, TMC operations simulation, quick clearance toolkit and workshop, incident management virtual training, operations academy, and freight academy.

2.1.3 Benefits/Outcomes

Since its development, the I-95 Corridor Coalition has provided numerous benefits to the multi-modal transportation needs within the Corridor, including:

- Efficiency through coordination between multiple agencies.
- Support and technical assistance from member agencies.
- Shared research and development through the use of pooled funding.
- Peer to peer networking between different agencies and organizations.
- The coordinated training programs and training resources (such as the quick clearance training and toolkit and operations and freight academies). These programs are designed for agency staff (consultants not allowed!!!) and are open to agencies throughout the country.
- The I-95 Corridor Coalition has established a 'centralized resource' for agencies to provide a clearinghouse of info and corridor-wide databases to facilitate information sharing for member agencies.

2.2 North/West Passage Program

http://www.nwpassage.info

The North/West Passage (NWP) Program began in 2002 when a group of transportation officials met to discuss development of multi-state transportation program. Minnesota DOT led the initial development of the NWP Program as an extension of the Minnesota Guidestar Board, which is Minnesota's ITS Program. In 2003, the NWP was established as an FHWA Transportation Pooled Fund (TPF) study. The NWP Program is predominantly a rural corridor and has similar issues related to traffic management, traveler information, and commercial vehicle operations as the I-80 Winter Operations Coalition. The following sections outline lessons learned from the NWP Program and should be considered when forming the I-80 Winter Operations Coalition.

Initially, the purpose of the NWP Program was to utilize effective techniques for sharing, coordinating, and integrating traveler information along I-90 and I-94 across state borders (Minnesota, North Dakota, and Wisconsin). Although the NWP Program was formed to address traveler information across state borders, long term goals of the Coalition include maintenance and operations, planning, and programming. The NWP Program provides an outlet to guide and coordinate states' projects within the corridor by developing standards and utilizing effective communication across state borders.

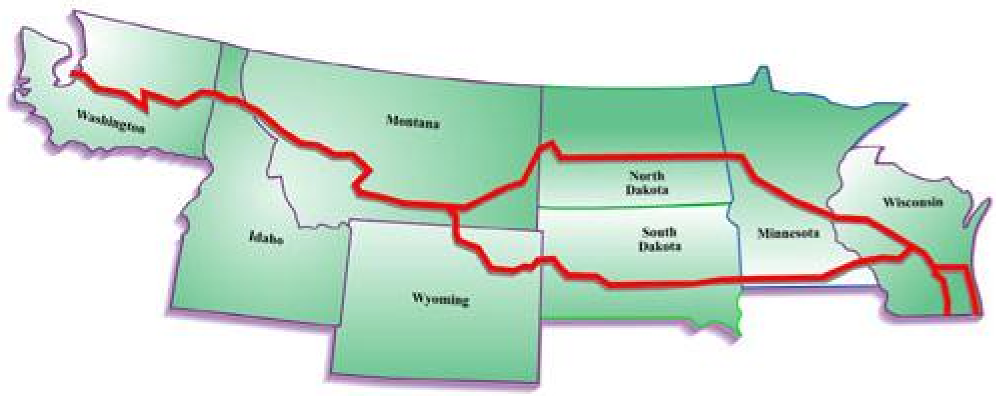
"The goals of the NWP Program are to:

- Integrate traveler information systems that can provide information appropriate to the location and need of the traveler
- Develop and promote cross-border jurisdictional cooperation and coordination in the planning, deployment, operations, and maintenance of ITS infrastructure
- Integrate ITS projects for the North/West Passage Corridor in the state, regional, and local planning and programming processes."

The NWP Program includes all states along I-90 and I-94 from Wisconsin to Washington. **Figure 3** shows the NWP Program member states, which include:

- Idaho
- Minnesota
- Montana
- North Dakota
- South Dakota
- Washington
- Wisconsin
- Wyoming

Figure 3 – NWP Program Member States



Source: 2009 North/West Passage Progress Report

2.2.1 Roles and Responsibilities

Membership in the NWP Program is currently limited to DOTs; however, other organizations are sometimes brought in on a project-specific basis.

There is a Steering Committee that is comprised of one representative from each state that financially contributes to the Coalition. Each member state is allowed one vote on all program issues. The Steering Committee meets monthly or as necessary to address Coalition issues.

A single state approved by the Steering Committee serves as the Program Administrator. The current Program Administrator is the Minnesota DOT.

A Stakeholder Group advises the Steering Committee on important matters. Members of the Stakeholder Group are identified and invited to participate by the Steering Committee. Stakeholder Group Members can include: additional individuals from participating organizations, individuals from other state and local agencies within the corridor, university research organizations, and private organizations deemed to be direct stakeholders in the NWP Program.

Over the years, members believe it is beneficial to have two to three champions from each state involved in the Coalition. This helps with transition if people leave their organization, and keeps the momentum going between conference calls. Frequent conference calls also help with the transition. The Coalition has also felt the project leaders should not be members of the steering committee.

Even though the initial coalition discussions have focused primarily on maintenance and operations, there might be a future expansion of the coalition that could include public information/communications groups, incident management, etc. This transition may open up involvement in the Coalition to others within the DOT that have an interest.

2.2.2 Frequency of Meetings

The NWP Program has one in person meeting per year. The rest of the meetings are held by teleconference. Over the years, the NWP Program has adjusted meeting formats and frequency. In general, there are monthly teleconference calls, as the time lapse between by-monthly or quarterly teleconference calls can become too lengthy.

2.2.3 Funding

The current arrangement for the NWP Program is that each state commits $25,000.00 per year to be a member. It is important to note that some states have continued to contribute more than the annual dues. This membership fee covers travel arrangements for the yearly Coalition Workshop/Conference, covers project match fees, and consultant fees. Although travel is covered under the yearly membership dues, it is a challenge to organize travel arrangements for the member state DOTs.

The NWP Program is a FHWA Transportation Pooled Fund (TPF) Study. The first Work Plan totaled $100,000 from three member states. As the Coalition grew, membership grew to eight states and a budget of $450,000 for Work Plan II and III combined. Work Plan IV projects have anticipated completion dates in 2009, and have a member agency budget of $200,000. **Table 1** summarizes the member agency funding for the NWP Program. It is important to note that the NWP Program is a TPF Study and receives grant funding in addition to the member agency funding outlined in **Table 1**.

Table 1 – NWP Program Member Agency Funding

State	Work Plan I	Work Plan II and III	Work Plan IV
Idaho		$50,000***	$25,000*
Minnesota	$50,000*	$150,000*	$25,000*
Montana		$25,000****	$25,000*
North Dakota	$25,000*	$25,000*	$25,000*
South Dakota		$50,000*	$25,000*
Washington		$50,000*****	$25,000*
Wisconsin	$25,000**	$50,000***	$25,000*
Wyoming		$50,000***	$25,000***
Total	$100,000	$450,000	$200,000

** SP&R Dollars*
*** 80/20 I-90/94 Earmark Dollars)*
****Federal and State Dollars*
*****Unknown*
******State Dollars*
Source: North/West Passage TPF-5(190) Q3 2009 Status Report

2.2.4 Projects

Previously completed projects include:

- Corridor-Wide Consistent Major Event Descriptions
- CAD to Reporting System Integration Workshop
- *Clarus* Demonstration Initiative
- Cross Border Operations and Maintenance Collaboration Workshop

The Phase IV Work Plan was approved on April 30, 2008, and projects are anticipated to be completed by the end of 2009. The Phase IV Work Plan included the following projects:

- Traveler Information Website – Phase 2 and Center to Center Communications ConOps (to enhance the existing corridor-wide traveler information website: www.i90i94travelinfo.com)
- Call forwarding and Evaluation of Cross Border Information Requests
- North/West Passage Regional Permitting
- Expanded Corridor-Wide Truck Parking Facilities

2.2.5 Benefits/Outcomes

Members of the NWP Program have identified numerous benefits of participating in the TPF study including:

- Forum to share lessons learned
- Provided important contacts at other agencies
- Assisted in making revisions to road condition reporting phrases

- Provided the ability to share ITS experiences and operation and maintenance experiences
- Promoted data sharing between transportation agencies and public safety/law enforcement
- Developed a corridor-wide traveler information website (www.i90i94travelinfo.com)

2.3 West Coast Corridor Coalition

http://www.westcoastcorridors.org

The West Coast Corridor connects all three countries (Canada, United States and Mexico) in the North American Free Trade Agreement (NAFTA) and accounts for 40 percent of port-related freight in the United States. As such, a majority of the port related freight corridors are concentrated in large metropolitan areas along the Pacific Coast. The West Coast Corridor Coalition (WCCC) was established in November, 2001, to address goods movement in the Pacific states along I-5. The Coalition has since shifted its focus to all modes of transportation supporting the movement of people and goods within the west coast region.

The purpose of the WCCC is to provide collaborative solutions to transportation system challenges along the West Coast Corridor while working together to address mobility challenges in the member states.

"Specific WCCC objectives are to:

- Develop and mutually support a roster of "projects of corridor significance" that serve the nation and region.
- Share "best practices" in order to optimize of the capacity and performance of existing corridor system.
- Encourage joint effort and effective cooperation among West Coast state, regional and local governments and the private sector.
- Advocate for financing options to fund transportation system improvements serving the interests of the Coalition, including both additional funding and regulatory changes."

The WCCC consists of members from the four west coast states of Alaska, California, Oregon and Washington. **Figure 4** shows the WCCC member states.

Figure 4 – WCCC Member States

Source: www.westcoastcorridors.org

2.3.1 Roles and Responsibilities

The WCCC consists of a wide variety of transportation agencies including: DOTs, ports, regional transportation planning agencies, and MPOs. The WCCC contains a Board of Directors, Executive Committee, and three Committees (Federal Relations Committee, Goods Movement Committee, and the ITS, Operations, and Environment Committee).

2.3.2 *Frequency of Meetings*

The Board meets once or twice a year to discuss approval of budget, work program, and significant changes in the organization.

2.3.3 *Funding*

Since inception, the WCCC received funding from federal appropriation and matching provided by some of the member organizations. In the April 2009 Business Plan, there was indication that a new funding source must be identified, whether it be through federal funding programs (energy, homeland security, freight), "pooling" planning and research resources, or membership fees.

2.3.4 *Projects*

Following are some projects that have been recently completed by the WCCC:

- Corridor-wide Trade and Transportation Study highlighting freight challenges, April 2008
- Clean, Green and Smart Best Practices, June 2009
- Business Plan, April 2009

2.3.5 *Benefits/Outcomes*

The WCCC has allowed a variety of states and agencies to join forces to address the challenges of congested rails, border crossings, seaports and roadways throughout the West Coast. The West Coast economy is sixth largest economy in the world, consisting of $2.2 trillion USD in 2006. Coordination between the various agencies is key to the successful movement of people and goods throughout this congested corridor.

2.4 Aurora Program

http://www.aurora-program.org

The Aurora Program is an FHWA TPF program. The Aurora Program was established in 1996 and currently includes U.S., Canadian and European agencies.

The purpose of the Aurora Program is to bring together agencies to conduct shared research, development and deployment of road and weather information systems (RWIS). Like many other coalitions, the Aurora Program is a TPF program which allows the financial resources from multiple agencies to be pooled together to fund RWIS-related programs.

The Aurora Program includes members from U.S., Canadian, and European agencies. Following is a list of members at the time this document was prepared.

- Alaska DOT and Public Facilities
- Illinois DOT
- Indiana DOT
- Iowa DOT
- Michigan DOT
- Minnesota DOT
- Ohio DOT
- Ontario Ministry of Transportation
- Pennsylvania DOT
- Quebec Ministry of Transportation
- Swedish Road Administration
- Utah DOT

- Nevada DOT
- New York State DOT
- North Dakota DOT
- Virginia DOT
- Wisconsin DOT

2.4.1 Roles and Responsibilities

The Aurora Program is comprised of transportation agencies, universities, and weather services in the U.S., Canada, and Europe. There are three levels of membership: full membership, associate membership, and visitor status.

- **Full Membership** is open to all transportation-related agencies. The yearly membership fee is $25,000.00. This membership fee is utilized to leverage funds to conduct large-scale research projects.
- **Associate Membership** is open to research and non-profit public entities, such as universities or other research institutes. All associate members must be nominated by an active Aurora Program full member, and do not pay membership fees.
- **Visitor** status is open to public organizations interested in becoming full members. The visitor program allows potential full members to attend one general meeting to gain an understanding of the program prior to committing to full time membership.

The structure of the Aurora Program consists of the executive board and technical project committees.

- The **Executive Board** contains one voting member from each full member agency. The executive board is responsible for directing the program and projects of the coalition.
- **Technical Project Committees** are responsible for specific project related work. A "Champion" is assigned from each technical project committee to be responsible for each project.

2.4.2 Frequency of Meetings

The Aurora Board meets in person on a yearly basis, and has additional web meetings throughout the year.

2.4.3 Funding

Each agency is required to contribute $25,000.00 per year for full time membership. Most agencies use SP&R funding; however, they are also allowed to make in-kind contributions (such as equipment or personnel) in lieu of membership fees. The Aurora Program is currently looking into the feasibility of attracting private sector contributions and federal grants to increase funding.

2.4.4 Projects

The Aurora Program has completed a variety of projects relating to RWIS including:

- Guidelines for Testing, Installation, Maintenance, and Calibration of Pavement Sensors
- Integration of Road Weather Information with Traffic Data
- Update of SHRP H-350 and H-351 – benefit-cost assessment for weather information in winter road maintenance.

Many of the projects that are currently underway were conceived at the 2007 National Winter Maintenance Peer Exchange and include:

- Evaluation and Inter-comparison of the Lufft R2S Microwave Precipitation Sensor
- Road Weather Information Outreach/Second Peer Exchange
- Knowledge Base for RWIS Programs and Environmental Data Loggers
- Road Weather Education Enhancements and Dissemination
- Further Development of Pavement Precipitation Accumulation Estimation System
- Salinity Sensor Improvements and Development
- Review of Friction Detection Technologies

2.4.5 Benefits/Outcomes

The Aurora Program has allowed a number of U.S., Canadian, and European agencies to pool their agency's financial resources to address RWIS-related research, development, and deployment. In addition, the coalition has allowed member agencies to develop relationships with national and international, public and private leaders in RWIS equipment, decision support systems, standards, and training

2.5 *Clarus* Initiative

http://www.clarusinitiative.org

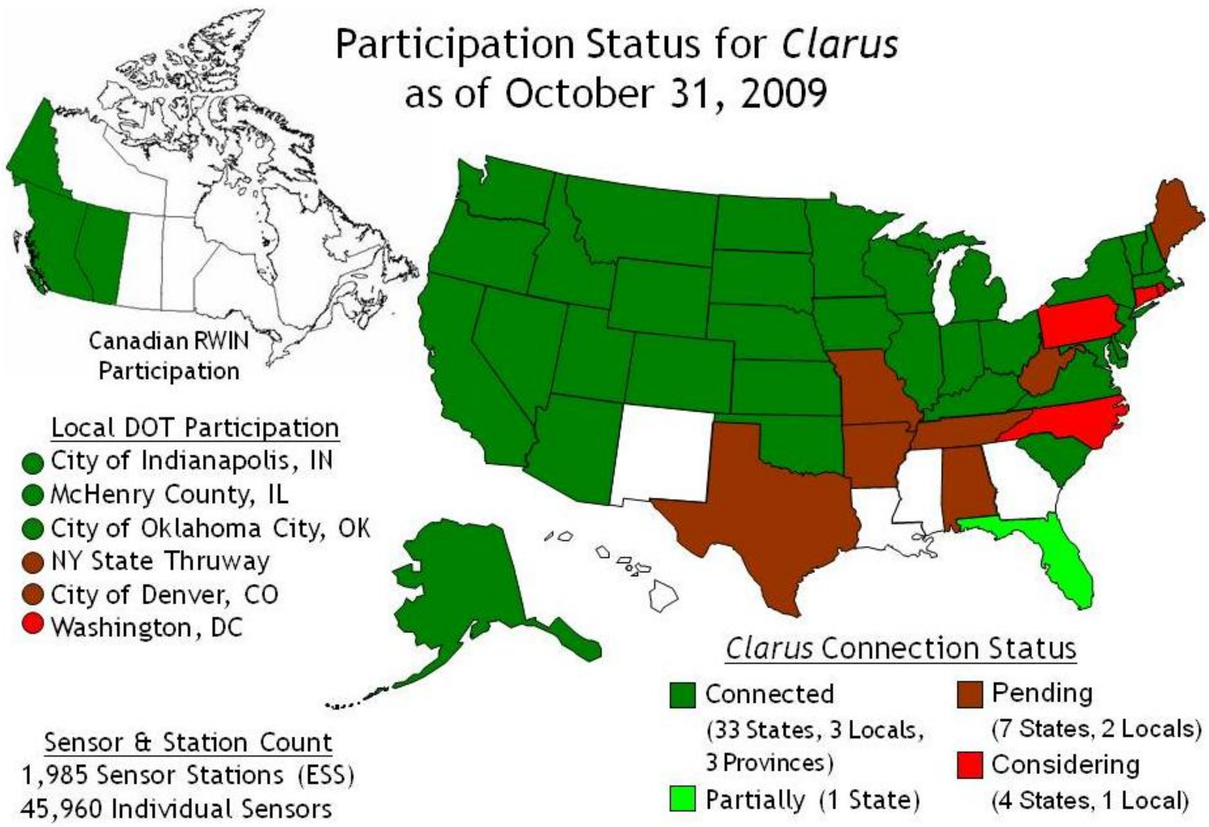
The *Clarus* Initiative was established by the USDOT in 2004 in conjunction with the FHWA RWIS program and the ITS Joint Program Office. *Clarus* means "Clear" in Latin.

The primary goal of the *Clarus* Initiative is to create a National surface transportation weather observing and forecasting system through the creation of partnerships between transportation and weather agencies. The *Clarus* Initiative strives to place all regional/nationwide collection of all state-funded transportation-related observations (atmospheric, road surface and hydrologic) into a single database. As such, the *Clarus* Initiative focuses on requirements for gathering weather data, systems engineering, and database design for federal, state, academia, and private sector weather information providers.

The RWIS requirements that have been developed aid with the collection of existing and future weather data. The *Clarus* Initiative also tests technologies for fixed, mobile, and remote sensing of weather conditions on surface transportation.

The *Clarus* Initiative currently has representatives from a majority of states as well as some participation from Canadian providences. **Figure 5** shows the participants in the *Clarus* Initiative as of October 31, 2009. At the time this document was prepared, there were 33 states, three local participants, and three provinces connected to the *Clarus* system accounting for 1,985 ESS sensor stations and 45,960 individual sensors.

Figure 5 – *Clarus* System Participants



Source: www.clarusinitiative.org

2.5.1 Roles and Responsibilities

The structure of the *Clarus* Initiative consists of the Initiative Coordinating Committee (ICC) and Project Task Forces.

- The **ICC** is comprised of meteorological and transportation experts from the public, private, and academic sectors. The ICC provides expertise and guidance on the *Clarus* Initiative. They are responsible for providing consultation, reviewing projects, and performing outreach in addition to verifying that project task forces are on schedule, under budget, performing their tasks. The ICC attends one annual meeting.
- A **Project Task Force** consists of eight to ten people involved with the development of a product or task. Each project task force creates an application that is reviewed by the ICC. If approved, a project task force "leader" is created to guide the task force (conference calls, e-mails, and other communications) to advance the development of the product or task.

2.5.2 Frequency of Meetings

The ICC attends one annual in-person meeting with web conferences throughout the year, as needed. Project Task Forces meet as needed to complete their product or task.

2.5.3 Funding

The USDOT funds the *Clarus* program through ITS program funds from the ITS Joint Program Office. There is also a *Clarus* Connection Incentive Program (CIP) which provides grants to states to participate in regional demonstrations and deployments.

2.5.4 Projects

The *Clarus* Initiative projects include system design, design review, design proof of concept, multi-state regional demonstration, and model deployment of RWIS systems. Several specific projects of the *Clarus* Initiative include:

- Development of Environmental Sensor Station (ESS) network Guidelines
- Metadata Task Force Data Dictionary

The *Clarus* Initiative has also undertaken Regional Demonstration Projects to evaluate the performance of the *Clarus* system design. The Regional Demonstration Projects will allow the ICC to test the system in an operational environment, where users are placing high demands on the system to access RWIS data. After the Demonstrations Projects were complete ConOps guides were created for each project. The following three demonstration projects were undertaken:

- Alaska – Canada (ALCAN) Highway Road Weather Portal ConOps
- Aurora Regional Demonstration Team and ConOps
- NWP Program Demonstration Team and ConOps

Valuable information obtained from the Regional Demonstration Projects has been utilized to create the Final Design and Model Deployment for the *Clarus* network in different regions of the country.

2.5.5 Benefits/Outcomes

The *Clarus* Initiative has created valuable partnerships between the transportation and meteorological industries. By working together, states have been able to modernize and integrate road condition observations; standardize weather data formats, communications, and network architecture; and disseminate road weather information to surface transportation system operators. As a result, timely and accurate road condition and weather information is now available to the users of the surface transportation system.

2.6 Maintenance Decision Support System Pooled Fund Study

http://mdss.meridian-enviro.com/pfs/

The Maintenance Decision Support System (MDSS) Pooled Fund Study was initiated in 2002 by South Dakota and five member states. South Dakota is still the lead for the MDSS Pooled Fund Study. The purpose of the Pooled Fund Study is to:

- Assess the need, benefits, and receptivity for a MDSS
- Define functional and user requirements for a MDSS
- Build and evaluate an operational MDSS that will meet requirements from participating state DOTs

- Improve the ability to forecast road conditions based on changing weather and maintenance treatments

The ultimate goal of the Pooled Fund Study is to create a fully functional MDSS to support the needs of transportation agencies.

Table 2 lists the states that are involved in the MDSS Pooled Fund Study along with the number of MDSS routes contained in each state.

Table 2 – MDSS Member States and Routes

State	MDSS Routes (2008-2009)
California	6
Colorado	108
Indiana	156
Iowa	65
Kansas	18
Kentucky	5
Minnesota	185
Nebraska	101
New Hampshire	7
New York	17
North Dakota	77
South Dakota (Leader)	80
Virginia	9
Wyoming	68

2.6.1 Roles and Responsibilities

Members must contribute financially, intellectually, conduct field trials, and provide intellectual property stewardship.

2.6.2 Frequency of Meetings

There are three project panel meetings per year along with conference calls, technical product reviews, and technology assessments.

2.6.3 Funding

Member states must contribute financially and intellectually as well as conduct field trials of the MDSS.

2.6.4 Projects

MDSS reports road surface conditions, describes actual maintenance treatments, provides past and present weather conditions, predicts weather events and pavement conditions, recognizes resource constraints, identifies feasible maintenance treatments, and communicates recommendations to supervisors and workers.

Analysis of MDSS Benefits and Costs

2.6.5 Benefits/Outcomes

Studies have shown that MDSS allows DOTs to achieve the same or better level of service with less material and effort. Studies in New Hampshire, Colorado and Minnesota have shown extremely high Benefit/Cost ratios.

Member states have experienced the following benefits:

- Shared research and development through the use of pooled funding
- Opportunity to test MDSS
- Peer networking and learning between state agencies and private entities
- Forum to share research and technology information

In addition, use of the MDSS can benefit the following areas:

- Safety
- Mobility
- Productivity
- Efficiency
- Energy and the Environment
- Increase Customer Satisfaction

2.7 ENTERPRISE

http://enterprise.prog.org/

ENTERPRISE was established as a Transportation Pooled Fund Study in 1991 between four states with common interests in developing, evaluating, and deploying ITS technologies. Since inception, ENTERPRISE has maintained a strong focus on rural states and ITS applications. Over the years, ENTERPRISE has grown to include Canadian and European agencies; however, its focus still remains on ITS.

Some of the goals of the ENTERPRISE program include the following: increase highway safety, reduce highway congestion, reduce environmental impacts of travel, support research and development of advanced technologies for use in solving transportation problems.

The following agencies are members of the ENTERPRISE Executive Board:

- Arizona DOT
- Colorado DOT
- Federal Highway Administration
- Iowa DOT
- Kansas DOT
- Michigan DOT
- Ministry of Transportation Ontario
- Minnesota DOT
- Transport Canada
- Virginia DOT
- Washington DOT
- Rijkswaterstaat, Dutch Ministry of Transportation

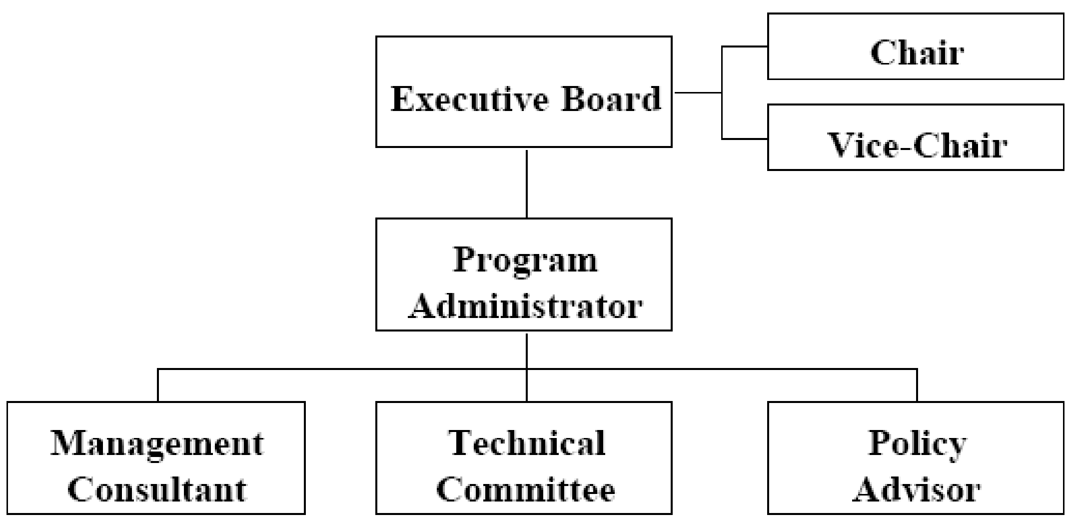
Maricopa County, Arizona (MCDOT) is a local government agency that participates through Arizona DOT and is not a full voting member.

2.7.1 Roles and Responsibilities

The organizational structure of ENTERPRISE is summarized below. **Figure 6** graphically depicts the organization structure.

- The **Executive Board** consists of one voting member from each full member agency. The Executive Board is responsible for directing the program and projects of the coalition.
- The **Program Chair** and **Vice-Chair** are elected by the Executive Board. The Program Chair serves as head of the board, and Vice–Chair is responsible for supporting the Chair and temporarily assuming Chair duties in periods of absence. Bill Legg of Washington DOT currently serves as the Program Chair.
- The Executive Board delegates a **Program Administrator** who is responsible for the day-to-day management of the coalition including contracts, budget, and travel authorization. The current Program Administrator is the Iowa DOT.
- **Technical Committees** are responsible for specific project related work, and are created by the Executive Board.
- The **Management Consultant** provides support to the Executive Board, Chair, Program Administrator, and Technical Committees.

Figure 6 – ENTERPRISE Organizational Structure



Source: http://enterprise.prog.org/

2.7.2 Funding

Active members must contribute $30,000.00 or more per year to the Program. For a designated member of the Board to continue active membership, the participating entity must contribute at least $30,000.00 per year. Pooled funding is derived from contributions received from participating entities.

2.7.3 Projects

ENTERPRISE defines and develops projects based on review of state and provincial plans, proposals of ENTERPRISE members, and based on FHWA and Transport Canada needs/interests.

Projects are considered on an annual basis as part of the development of an annual work plan and schedule. A project may be fast-tracked in the event that a project with significant benefits is identified. All projects are ranked by the member agencies on a 0-20 point ranking system with the following selection criteria:

- Value to members
- Suitability to ENTERPRISE
- Project feasibility
- Validity of approach
- Cost realism

After the projects are ranked, the Program Administrator analyzes the results and reports to the members.

The ENTERPRISE Pooled Fund Study has completed a variety of ITS projects including:

- Multi-Jurisdictional Mayday (MJM) Project
- Integrating NTCIP Compliant Hardware
- Weather and Road Information Coordination –WRIC

Current projects include:

- Renewal Energy for Rural ITS Applications
- IP Cameras – Developing Low-Cost Satellite IP Cameras (SPIC)
- Nationwide ATIS
- Virtual TMC

2.7.4 Benefits/Outcomes

The ENTERPRISE Pooled Fund Study has facilitated the sharing of technological advances and institutional experiences gained from ITS projects by allowing agencies to share funding, resources, and risks.

2.8 TMC Pooled Fund Study

http://tmcpfs.ops.fhwa.dot.gov/

The purpose of the TMC Pooled Fund Study is to provide a forum for local traffic management agencies to focus on traffic signal control systems, freeway management, and multi-modal TMCs.

Membership in the TMC Pooled Fund Study is open to the FHWA and state/districts that have committed funding to the TMP Pooled Fund Study. Other entities that seek to contribute funds to become members (toll agencies, cities, counties, port authorities, or others associated with operation of transportation control centers) are considered for membership on a case-by-case basis.

Membership consists of the following 28 states plus the FHWA.

- Arizona DOT
- Caltrans
- Connecticut DOT
- Delaware DOT
- FHWA
- Florida DOT
- Georgia DOT
- I-95 Corridor Coalition
- Idaho Transp. Department
- Illinois DOT
- Indiana DOT
- Kansas DOT
- Kentucky Transp. Cabinet
- Michigan DOT
- Minnesota DOT
- Missouri DOT
- Nebraska DOR
- Nevada DOT
- New Jersey DOT
- New York State DOT
- North Carolina DOT
- Pennsylvania DOT
- Rhode Island DOT
- Tennessee DOT
- Texas DOT
- Utah DOT
- Virginia DOT
- Washington State DOT
- Wisconsin DOT

2.8.1 Roles and Responsibilities

The FHWA Office of Research, Development, and Technology serves as the Program Administrator and administers resources under the direction of the Members. In addition to being responsible for the day-to-day administration of the TMC Pooled Fund Study, the Program Administrator drafts RFPs and coordinates the proposal review process.

Each membership state has a technical representative chosen by their respective participant state and the FHWA.

The TMC Pooled Fund Study aims to utilize consensus building as opposed to formal voting. The Chair works with members to develop consensus decisions regarding projects and budgets. If voting is necessary, a 2/3 majority of assembled participants is required.

2.8.2 Frequency of Meetings

The members meet on an annual basis to review current project progress and select new projects. More frequent teleconferences and meeting is required for those directly involved in project teams for the TMC Pooled Fund Study.

2.8.3 Funding

Participating agencies contribute to the pooled fund at a level deem appropriate by the Study using SP&R funding.

2.8.4 Projects

Consensus is the most important step in choosing projects. The TMC Pooled Fund Study strives to choose a group of projects, that when completed together, addresses the needs and concerns of all member agencies.

Members are responsible for approving project budgets and work plans, as well as, creating and terminating project teams as needed.

Completed projects include:

- Changeable Message Sign Operation and Messaging
- Multi-State, Statewide and Regional TMC Concept of Operations Requirements
- TMC Operations Manual
- TMC Performance Monitoring, Evaluation and Reporting Handbook

Current projects include:

- Driver Use of Real-Time En-Route Travel Time Information
- Methodologies to Measure and Quantify TMC Benefits
- Procuring, Managing, and Evaluating the Performance of Contracted TMC Services
- Roles of TMCs in Emergency Operations
- TMC Human Factors Design Guidelines: Requirements Analysis

2.8.5 Benefits/Outcomes

The TMC Pooled Fund Study has many benefits including:

- Completion of 19 projects in seven years
- Providing leadership and coordination with other TMC interests
- Promoting and facilitating technology transfer related to TMC issues on a national level

3. TRANSPORTATION POOLED FUND PROGRAM

http://www.pooledfund.org

The Transportation Pooled Fund (TPF) program is sponsored by the FHWA, TRB, and AASHTO. The TPF program allows federal, state, and local agencies and organizations to combine resources to support transportation research studies. Typically, 20 percent of the funding is supplied by the local agencies and 80 percent is a federal match. As a result, agencies can leverage their funding to complete studies with less funding requirements from individual states. In addition, a TPF fosters the creation of partnerships between different states and agencies with common interests.

A TPF must include more than one state transportation agency, federal agency, or other agency (MPO, college, university, or private company). Any federal, state, regional or local transportation agency may initiate a TPF program, and companies, universities/colleges may partner with transportation agencies to take part in the TPF program.

Agencies must commit funds or other resources (such as in-kind contributions) to conduct the research, planning and/or technology transfer activities. A TPF study cannot repeat a previous study unless the study provides new information advancing the previous investigations

According to the TPF Program, the following general steps must be completed to qualify for the TPF Program.

- Identify partner agencies
- Develop a problem statement/proposal. This problem statement/ proposal should include the following:
  - Title
  - Duration
  - Deliverables
  - Implementation plan
  - Sponsor information
- Determine who will lead the project (state-led, FHWA-led, or TRB-led).
- If accepted, FHWA will establish the project as a TPF project. The FHWA will then:
  - Process funding commitments (usually 80 percent federal, 20 percent non-federal)
  - Assign a project number
  - Assign a technical liaison
  - Determine if the project will be approved for 100 percent state planning and research (SP&R) funds

The TPF program may be one option that the I-80 Winter Operations Coalition explores. This will require member states to commit funds to the program.

4. LESSONS LEARNED

The following sections include lessons learned from the various coalitions that can be used to guide the I-80 Winter Operations Coalition as it moves forward.

4.1 Organization

Other coalitions have identified two to three champions from each member organization provide maximum benefit. Multiple champions provides 'back-up' at the organization, helps maintain continuity if individual roles change within the organization, and/or provides organization representation if all champions cannot make it to a particular meeting.

4.2 Governance Structure

As the I-80 Winter Operations Coalition is forming, it is recommended that a steering committee and champions at the task force level be created. Providing too much structure and too many committees/boards could cause the coalition to become too top heavy with multiple oversight boards. This is a small coalition (by many standards), and needs to be mindful that members have full-time jobs outside of the coalition activities.

4.3 Frequency of Meetings

Most coalitions hold one annual in-person meeting and multiple quarterly or monthly teleconferences or web conferences.

It is recommended that Coalitions hold monthly steering committee calls as opposed to every other month. This is because members cannot make all of the conference calls, and if someone misses a conference call that is on an every other month schedule, it can be four months before they are on a call and that can be too much time to pass between information sharing. The downside to monthly conference calls is that sometimes there is not always a lot to discuss each month, but it brings everyone to the table and keeps the momentum going.

There is tremendous value to in-person meeting, but there is a need to recognize cost and time factor associated with in-person meetings. It is recommend a combination of in-person meetings/conferences, teleconferences, web or video conferences, etc. to maintain communications and interactions in a very cost effective manner.

4.4 Funding

The current arrangement for many coalitions is that each state commits $25,000.00 per year to be a member. This membership fee covers travel arrangements for the yearly Coalition Workshop/Conference, covers project match fees, and consultant fees. Although travel is covered under the yearly membership dues, it is a challenge to organize travel arrangements for the member state DOTs.

The downside of the current set-up for most coalitions is that states have to recommit annually. Each year, coalition members have to re-sell the coalition to management, and it can be a struggle to show management the benefit when projects do not always occur in each member state every year. In addition, the differentiation between multiple pooled funds can be hard for decision makers to understand. If there is overlap between coalitions of member states, it could be beneficial to look for ways to develop joint projects between the two coalitions to benefit the members as well as demonstrate to decision makers that the two coalitions are aware of each other and working together for a common goal.

It is important to clearly and concisely explain benefits of membership to decision makers. The I-80 Winter Operations Coalition could explore and discuss the option to try a four to five year commitment from each state for funding the Coalition. This would save time and effort each year when funding is established between the states.

4.5 Projects

One of the challenges with Pooled Funds is that the work planning process is constantly going on. The work planning process includes suggesting projects, work planning, project approval, and the execution of projects. It can sometime feel like the Coalition is in perpetual planning and work planning mode. Another challenge is prioritizing projects. Some may be of greater benefit to a limited number of partners; projects that are funded with collective monies need to demonstrate a benefit to the coalition as a whole.

As the Coalition is taking shape, it is a good idea to plan projects that can capture the low hanging fruit. For example, the NWP Program held a CAD-TMC two day workshop with two reps from each state (one DOT employee and one law enforcement employee). The two day workshop focused on lessons learned and effective communication. After the workshop, the NWP Program published the results and sent states a mini-plan for coordinating communication. The project cost approximately $20,000.00, of which $10,000.00 was travel.

It is also important to define the identity of the Coalition in relation to what types of projects the Coalition wants to take on. Most coalitions start with two to three smaller projects per year (less than $30,000.00). As the coalition matures, they start looking at completing larger joint deployment projects. The larger joint deployment projects can become more complicated as it can be difficult to work out some of the legal issues, such as who maintains the equipment or can the Coalition sign a two year agreement for a website when they have yearly business planning process.

Although the projects completed by the various coalitions described in this document are very innovative and would have been very tough to complete individually, it is still hard for states to commit to the coalitions on a yearly basis.

Moving forward, the Coalition should determine what types of projects and/or programs they want to focus resources on. For example, developing external tools (like an I-80 traveler info web site) or conducting research projects. In addition, the Coalition will need to establish coalition resources to conduct projects and provide sustainability for the Coalition.

TECHNOLOGIES TO HELP MITIGATE WEATHER IMPACTS ON ROADS

FHWA Road Weather Management Program
www.ops.fhwa.dot.goc/weather

1. URBAN AND RURAL FREEWAY MANAGEMENT

1.1 Central Traffic Management

The TOC/TMC is the nerve center of most freeway management systems. The TOC/TMC monitors and controls traffic and the road network. The TOC/TMC collects and processes freeway system data, combines it with other operational and control data, synthesizes it to produce "information," which is distributed to stakeholders such as the media, other agencies and traveling public. TOC/TMC staff uses the information to monitor freeway operations and to initiate control strategies that affect operational changes. Agencies also coordinate their responses to traffic conditions and incidents through the TOC/TMC.

There are organized regional TOC/TMCs in each of the states included in the I-80 Winter Operations Coalition. In California and Utah these are considered TMCs. In Nevada, these are Regional Operations Centers. In Wyoming, it is the WYDOT Operations Center. These facilities monitor and control freeway traffic control systems including ramp metering, CCTV cameras, traffic recording devices, DMS, and HAR. Each center has different hours of operation and it should be evaluated what information and sharing of device control should be accommodated for across state lines based on those hours of operations and permissions levels during those hours.

1.2 Reporting Systems

Reporting systems are defined as systems for facilitating the real-time electronic reporting of surface transportation incidents to a central location for use in monitoring the event, providing accurate traveler information, and developing an appropriate response. The importance of reporting systems has been emphasized in Section 1201 of SAFETEA-LU. The federal legislation requires the Secretary of Transportation to establish data exchange formats to ensure that the data provided by highway and transit monitoring systems, including reporting systems, can be readily exchanged to facilitate nationwide availability of information.

There are currently a number of reporting systems used by states within the I-80 Winter Operations Coalition corridor. These reporting systems typically provide the database that supplies info to the different 511/traveler information tools for each state or region. Reporting systems are also an important tool in integrating incident information into TMC operations for better management of incidents and closures of I-80. The reporting systems used in each state include:

- California uses the Caltrans Highway Information Network (CHIN) provides daily adverse travel conditions information which is made available to telephone and internet (www.dot.ca.gov/hq/roadinfo).
- Nevada currently operates a statewide traffic and road closure information system available at www.safetravelusa.com/nv which is offered by Meridian.

- Nevada Highway Patrol road incident information for the state is located at www.nvdpspub.gov/nhp/roadhazard.aspx. Nevada does not have a centralized database but is currently evaluating opportunities for initiating one.
- Utah has Commuterlink which is the statewide resource for traffic, road, and weather conditions information. Utah offers the extensive capabilities of the Commuterlink system online at www.utahcommuterlink.com.
- Wyoming uses the Condition Acquisition Reporting System (CARS) which is a non-proprietary, standards-based reporting system that allows authorized users to enter, view, and disseminates critical road, travel, weather, and traffic information. CARS users access the system from any location using a standard web browser, which allows them to enter or view reports throughout the state.

1.3 Closed Circuit Television (CCTV)

CCTV cameras are typically distributed along the urban roadways, passes, and state borders to monitor and control traffic. They are also used by maintenance and law enforcement personnel to assess roadway conditions on the roadway without physically being at the location. CCTV cameras are most prevalent within the urban areas of the states to monitor congestion and incidents. All four states have strategically placed CCTV cameras on I-80 to assist in monitoring incidents related to severe weather in mountainous and remote areas. These CCTV cameras are operated and controlled by the operations centers in each state. These cameras are important traveler information tools for sharing video images with motorists and freight travelers. Interstate sharing of CCTV camera video images or control may be an important coordination technique pursued by the Coalition to share road condition information in a more timely and effective manner such as web-based.

1.4 Dynamic Message Signs (DMS)

DMS are another widely deployed technology along I-80 between California and Wyoming. DMS includes equipment distributed on and along the interstate that provides traveler information to drivers as well as can be equipped with detection capabilities to monitor and control traffic. They project information, such as roadway conditions, dynamic travel times, road closures and special event details. The DMS that are located along I-80 all have centralized communications (via fiber, wireless, or telephone leased lines) back to an operations center.

1.5 Highway Advisory Radio (HAR)

HAR consists of a low-power radio transmitter licensed for state use in the AM frequency. Signs along I-80 in relation to HAR transmitters in the area direct travelers to dial particular AM stations to hear short, pre-recorded messages that alert drivers of severe weather conditions, construction, incidents, or congestion. California operates one HAR in Nevada for westbound motorists on I-80. Utah has a number of HAR transmitters along the rural segments of I-80. In proximity to and in the direction of the state lines in Wyoming, there are HAR deployed along I-80 to inform travelers of road conditions controlled by the WYDOT Operations Center.

1.6 Communications Media

There are four different categories of communication currently utilized within the I-80 four states corridor. These categories are fiber, wireless, telephone and copper. Extensive fiber networks are mostly found in the larger urban areas within the corridor whereas wireless and telephone communications to rural devices typically are the method outside of urban areas. In many rural areas, commercial cellular service is unavailable or spotty at best which is typically where telephone dial-up communications to ITS devices are utilized. All of the states have radio communication utilizing a variety of frequencies including 150, 960 and 800 MHz.

2. INFORMATION DISSEMINATION

Transportation managers and information service providers disseminate road weather information to travelers in order to influence their decisions, such as mode, route selection, departure time, vehicle type and equipment (e.g., tire chains), driving behavior (e.g., decrease speed, increase following distance) and trip deferral. Managers utilize various technologies to furnish road weather advisories to travelers. Strategies include activation of flashing beacons atop static signs, posting warnings on Dynamic Message Signs (DMS), and broadcasting messages via Highway Advisory Radio (HAR).

Route-specific road condition reports and travel forecasts are often provided through state agency web sites and interactive telephone systems, including 511 - the national traveler information telephone number. All four states operate a 511 telephone system in which weather information and road condition information is updated regularly (not real-time) and at the following websites:

- California – www.sacregion511.org – real-time traffic provided by BeatTheTraffic.com, live traffic camera images, road conditions from CHIN, highway patrol traffic incident information, planned road work from CHIN, weather from National Weather Service
- Nevada – www.nv511.com – road work,
- Utah – www.utahcommuterlink.com
- Wyoming – www.wyoroad.info

Road weather information can also be delivered via other dissemination technologies, such as Personal Digital Assistants (PDAs), in-vehicle devices, and kiosks or displays in rest areas.

Types of weather-related data that is beneficial to TMCs include:

- Visualization for direct observation of weather conditions (e.g. constant display of weather radar or weather satellite images).
- Traffic surveillance equipment including CCTV cameras.
- Combination of observations from various weather sources, including generic and tailored weather information.
- Verified travel and road condition reports, such as lane closure, limited visibility, or reduced road friction taken from direct field reports.
- RWIS and ESS data and interpretation – wind speed and direction, cloud thickness, precipitation type and intensity, air temperature, dew point and humidity, and radar depiction.
- Road information – overall roadway condition, visibility or visible distance, pavement temperature, pavement condition (dry, wet, icy), road dew point, road freeze point, and/or road snow depth.

Weather reporting to the traveling public is a challenge due to a number of factors:

- Numerous reporting services and sites available – Provide different levels of details about weather conditions and sometimes different information based on the source. This creates a complicated scenario for the traveler to find the "best" information available on their own.
- Different naming conventions for weather conditions – Differences between the types of information that is provided to the public. Some states' 511 system might report pavement conditions as "icy" and others states' 511 system might report just atmospheric information such as temperature and precipitation. There are no adopted standards for how weather conditions should

be reported or what information should be collected on weather conditions as a baseline of data for reporting purposes.

- Provide baseline information – Camera images, closures, and forecasts help travelers quickly know about their route; whereas pavement conditions, watches and warnings, radar images may be helpful to a TMC but are generally not as easy to comprehend for the traveling public.

511 typically provides information on current and changing travel conditions and forecasts for upcoming weather events that are likely to impact the ability to travel. Weather information for 511 on a segment-by-segment basis needs to be focused on the travel impact of weather conditions. Many state DOTS also provide textual and graphical road weather information on the internet. The most advanced is WSDOT's 511 website which collects data from a variety of sources, and displays current and forecasted pavement and weather conditions on a color-coded statewide map. Also, interactive voice response technology to provide route-specific road condition reports and six-hour weather forecasts to drivers on highways is utilized as Weather Information Systems in many other states.

511 and web have been beneficial for communicating severe weather hazards or hazardous conditions. Winter road conditions on highways and weather forecasts are typically the most requested information items on 511 networks in states such as Washington, Idaho, Wyoming, and other winter weather states. In Spokane, Washington, 94 percent of travelers surveyed indicated that a road weather information website made them better prepared to travel and 56 percent agreed that the information helped them to avoid travel delays.

3. DECISION SUPPORT, CONTROL AND TREATMENT

In cold weather conditions, specifically snow and freezing rain, moisture on bridge decks and underpasses may freeze while adjacent roadways remain unaffected. In 2000, the FHWA Road Weather Management Program documented the weather information needs of 44 types of transportation managers in order to make 423 kinds of decisions as part of the Surface Transportation Weather Decision Support Requirements (STWDSR) project. By integrating environmental data with other data (e.g., traffic flow data, resource data, population data, topographic data) transportation managers can assess weather impacts on roadways to support their operational decisions. By using timely, accurate, route-specific environmental data in decision-making processes, managers can effectively counter weather-related congestion and delay, reduce weather-related crashes, and disseminate relevant information to travelers. The

Some Traffic Management Centers (TMCs) utilize Advanced Traffic Management Systems (ATMS) that integrate environmental data with traffic monitoring and control software. The program has sponsored projects to integrate weather into TMC operations. Traffic managers may access road weather data to make decisions about traffic control and motorists warnings. Control strategies alter the state of roadway devices to permit or restrict traffic flow and regulate roadway capacity. Advanced traffic signal control systems can be used to modifying traffic signal timing based upon pavement conditions. Weather-related signal timing plans modify cycle lengths, splits, and offsets to accommodate changes in driver behavior and decrease arterial delay. Traffic managers can reduce speed limits with Variable Speed Limit (VSL) signs and Dynamic Message Signs (DMS). When travel conditions are unsafe due to flooding, tornadoes, hurricanes, or wild fires, traffic and emergency managers may restrict access to affected bridges, specific lanes, entire road segments, or designated vehicle types (e.g., high-profile vehicles). Ramp gates, lane use control signs, flashing beacons, Highway Advisory Radio (HAR), and DMS are typically employed to alert motorists of weather-related hazards and access restrictions.

Treatment strategies supply resources to roads to minimize or eliminate weather impacts. The most common treatment strategies are application of sand, salt, and anti-icing chemicals to pavements to improve traction and prevent ice bonding. A portion of I-90 in Washington included a horizontal and vertical curve making black ice and pavement frost a cause of 70 percent of winter crashes at this site. Deployment of an automated anti-icing system eliminated up to 80 percent of snow and ice related crashes. *See the Idaho DOT Anti-Icing/Deicing Operations Case Study #5 for more information on this type of treatment strategy.* Maintenance vehicles can be equipped with plow blades, chemical storage tanks, spray nozzles, and material spreaders to clear roads of snow and ice. Another type of strategy is conducted by the Utah Department of Transportation (DOT). This agency outfits maintenance vehicles with gas cylinders containing compressed liquid carbon dioxide, which is sprayed into the slipstream of the truck to disperse fog. *See the Utah DOT Fog Dispersal Operations Case Study #4 for more information on this treatment strategy.*

The Road Weather Management Program completed a research study in 2005 to analyze how weather and emergency information was currently being used in Traffic Management Centers (TMC) throughout the country. The research documented the state of the practice in weather integration and identified advanced practices. The study concluded that successful integration of weather information allowed improve capability and preparation for incident management by Traffic Management Center (TMC) staff and dissemination of traveler information. More information can be found in the final report Integration of Emergency and Weather Elements into Transportation Management Centers (http://ops.fhwa.dot.gov/weather/resources/publications/ tcmintegration/index.htm). Recommendations from the study include building awareness and creating a culture within TMCs that acknowledges the value of weather information and makes integration a standard business practice, improving communications among the users of weather information in the TMCs and the field, developing guidelines and conducting self-assessment programs, and developing new concepts and tools to help facilitate the weather integration process.

In general, very limited integration and application of weather information for TMC operations were observed. In some cases where good examples of weather integration were found, the approaches taken by the agency were specific to the needs of the region or state. Clearly there is a need to advance the state of the practice and help agencies overcome the challenges associated with weather integration in TMCs. To address these challenges, the Road Weather Management Program initiated a project to develop a self-assessment guide to help TMCs evaluate their weather information integration needs and assist them in creating a plan to meet those needs. The guide, Integration of Weather Information in Transportation Management Center Operations: Self-Evaluation and Planning Guide (http://www.itsdocs.fhwa.dot.gov/ JPODOCS//REPTS_TE/14437.htm) was completed in 2008, and consists of the manual document and electronic self-evaluation that can be downloaded from the FHWA Web site. As part of the guide development FHWA worked with two TMCs to conduct a self-evaluation using the guide and develop a weather integration plan. The guide is currently being promoted and deployed around the country, with FHWA now working with at least 4 TMC's in conducting the self-evaluation and developing weather integration plans.

3.1 Maintenance Decision Support System (MDSS)

The MDSS prototype is a decision support tool that integrates relevant road weather forecasts, coded maintenance rules of practice, and maintenance resource data to provide winter maintenance managers with recommended road treatment strategies. MDSS offers maintenance personnel a ‘one stop shop’ that provides weather and pavement forecasts, and treatment recommendations within a single application that can be used for strategic planning 12-48 hours in advance of a storm or during a storm (0-12 hours). MDSS can also provide two-way communication links between maintenance supervisors and trucks using mobile data communication and automated vehicle location technology – snowplows are equipped with GPS that are capable of obtaining and reporting weather conditions and equipment status. Version 5.0 of the MDSS software is now available from the National Center for Atmospheric Research http://www.rap.ucar.edu/projects/rdwx_mdss/. MDSS generates information and recommendations based on predicted:

- Pavement temperature
- Pavement condition (e.g., pavement friction and snow accumulation)
- Weather impacts
  - Air temperature
  - Wind and gusts
  - Relative humidity and dewpoint
  - Precipitation (type, intensity, and amount)
- Pavement/bridge frost potential
- Blowing snow potential
- Treatment recommendations
  - Recommended treatment plan (such as plow only, chemical use, and prewetting)
  - Recommended chemical application amount
  - Timing of initial and subsequent treatments
  - Indication of the need to pre-treat or post-treat the roads

Commercial providers offer various approaches to MDSS. One approach is a web-hosted solution where software is operated at the commercial provider's site with agency access provided by the Internet. Another approach is a hosted client/server where part of the application operates on agency computers, but other parts run on a central server, typically web-hosted, at a commercial provider's site. A third alternative is for the agency to have the application completely installed and operated at its sites. Agencies may also choose to develop their own applications. The overall flow of the MDSS is described below (commercial products not based on this model may differ in structure but have similar functions):

- **INPUT –** Data input for the MDSS prototype includes meteorological and road observations and output from weather prediction models. This includes surface meteorological observations from National Weather Service and Federal Aviation Administration airport sites. These systems are updated at least once per hour. Input also includes both atmospheric and pavement data from DOT environmental sensor stations. Many of these stations have sensors to measure atmospheric, pavement, and water level conditions along roads. In some cases, data can be transmitted from maintenance vehicles regarding their locations and treatment activities and input to the MDSS.
- **SYNTHESIS –** All of the input data are then forwarded to the Road Weather Forecast System. This system has formulas that synthesize the information to create a forecast that contains all of the elements that are needed to begin treatment recommendation generation. Elements include: forecasted air temperatures, precipitation types and their probabilities, and wind speeds.
- **RECOMMENDATIONS –** The Road Condition and Treatment Module takes the forecasted weather elements and uses a computer model to predict road conditions (e.g., snow depth and pavement temperature). This model also generates recommended treatments and gauges the effectiveness of those treatments.
- **USER VIEW –** Once maintenance professionals settle on a treatment plan, MDSS presents recommendations in a user view in graphic, map, and narrative form. From here, users can view specific roads and weather parameters. The MDSS recommendations can be customized based on agency-defined policies and by capturing the knowledge of experienced staff. For example, agency policy may restrict the application of certain chemicals on specific routes

due to environmental concerns. Such restrictions can be reflected in treatment plans. If an agency is using mobile data communications/automated vehicle location, treatment recommendations can be sent directly to an operator in a truck in some vendor systems.

- **EXTRAS –** In some implementations of MDSS, the system can generate "what if?" scenarios. This capability allows a maintenance manager to modify the timing, chemical type, or application rate on any of the routes to see how the changes might affect the treatments or forecasted road conditions.

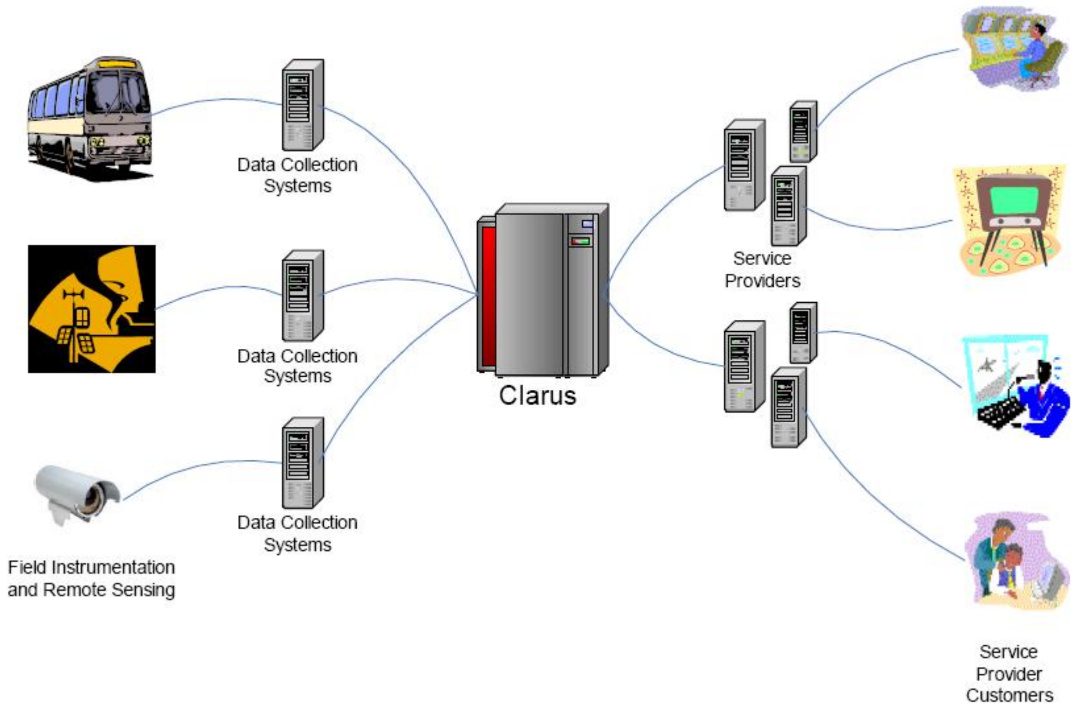
In 2007, 21 state transportation agencies were using or developing MDSS tools. Fourteen states have joined the MDSS Pooled Fund Study *(discussed in more detail in the Relevant Coalition White Paper included in this packet)* led by the South Dakota DOT to develop an enhanced version based on the federal MDSS prototype, while others were in the process of procuring the software or have contracted with private vendors for maintenance decision support capabilities.

Current and upcoming efforts associated with the FHWA MDSS effort include: (1) promoting deployment of the MDSS for winter road maintenance, and (2) expanding the scope of MDSS to become a Maintenance and Operations Decision Support System (MODSS) that supports other weather-related decision making, such as for summer maintenance and construction. FHWA recently released the *Maintenance Decision Support System (MDSS) Deployment Guide* (http://www.itsdocs.fhwa.dot.gov/JPODOCS/REPTS_TE/14439.htm) to assist agencies in adopting and implementing the system. The FHWA National Highway Institute (NHI) has also introduced a new online version of its *Principles and Practices for Enhanced Maintenance Management Systems Course* (http://www.tfhrc.gov/focus/oct08/04.htm) to help agencies enhance routine highway maintenance and operations.

3.2 *Clarus* Initiative

The Clarus Initiative was established by the USDOT in 2004 in conjunction with the FHWA RWIS program and the ITS Joint Program Office. The primary goal of the Clarus Initiative is to create a National surface transportation weather observing and forecasting system through the creation of partnerships between transportation and weather agencies. The Clarus Initiative strives to place all regional/nationwide collection of all state-funded transportation-related observations (atmospheric, road surface and hydrologic) into a single database. As such, the Clarus Initiative focuses on requirements for gathering weather data, systems engineering, and database design for federal, state, academia, and private sector weather information providers. The Clarus Initiative currently has representatives from a majority of states as well as some participation from Canadian providences. Currently there are 33 states, three local participants, and three provinces connected to the Clarus system accounting for 1,985 ESS sensor stations and 45,960 individual sensors.

The *Clarus* Initiative is essentially a plan to create a “network of networks” – much like the Internet – for surface transportation environmental data. Each of the weather networks will function autonomously; they will collect information and disseminate it internally without direction of dependence on *Clarus*. The *Clarus* System will collect, organize, and quality check the environmental data to be published by the system. The *Clarus* System will collect files at scheduled intervals usually between 10 and 30 minutes apart. There are required and optional metadata that are attached to data that is being sent to the *Clarus* System. Required metadata is to quality check and disseminate observations.



Source: Clarus Weather System Design – Detailed System Requirements Specification, December 2005, Page 9

Figure – Clarus Weather System Design

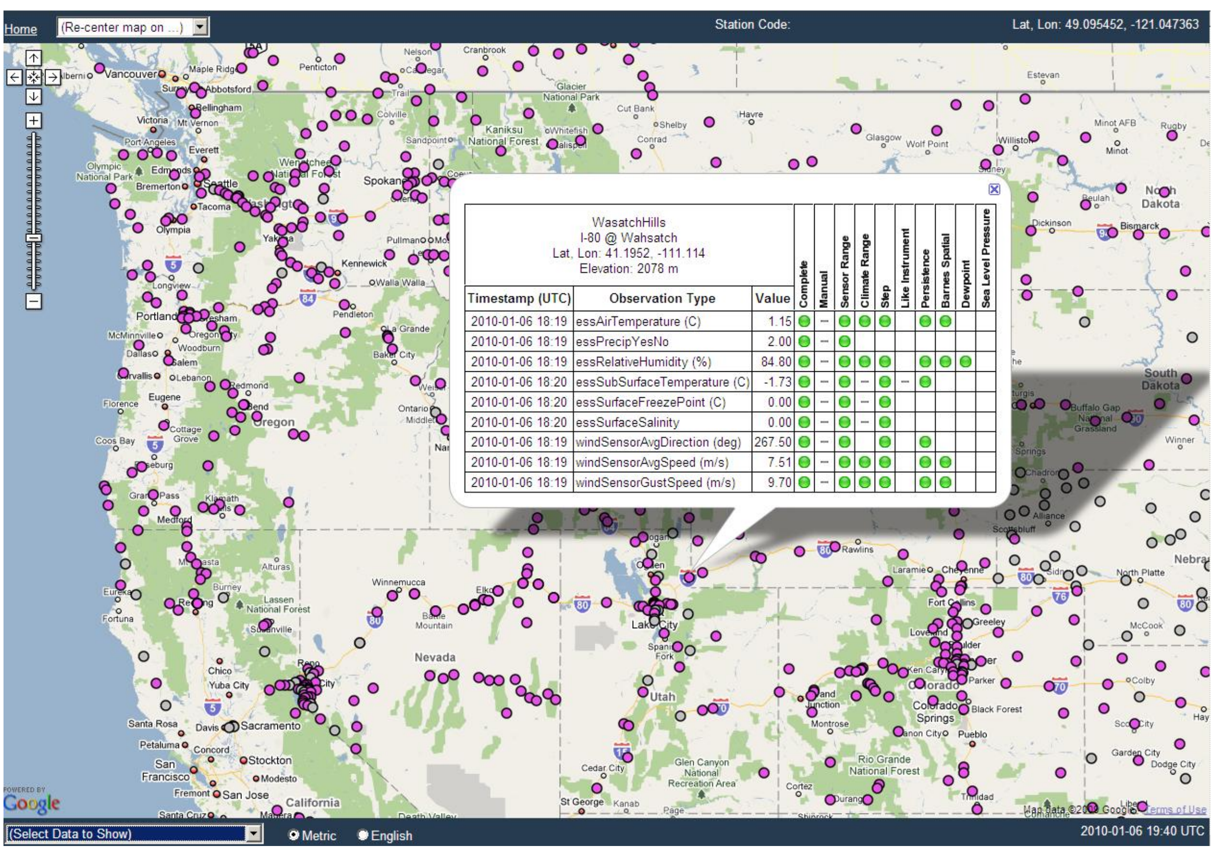


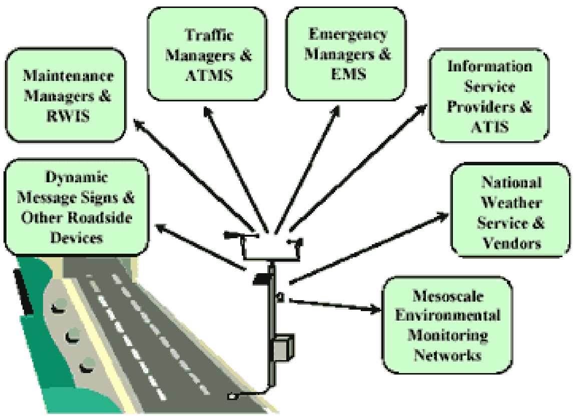
Figure – Clarus System Map View

4. Surveillance, Monitoring and Prediction

To make road weather management decisions, transportation managers must access data on environmental conditions from observing systems and forecast providers. Observing system technologies include fixed environmental sensor stations (ESS), mobile sensing devices, and remote sensing systems. Environmental observations ultimately support predictive information for decision support applications. Predictions of environmental conditions can be obtained from public sources, such as the National Weather Service and the National Hurricane Center, and from private meteorological service providers. Environmental data may also be obtained from mesoscale environmental monitoring networks, or mesonets, which integrate and disseminate data from many observing systems (including agricultural, flood monitoring and aviation networks). The NOAA Meteorological Assimilation Data Ingest System (MADIS) is a data management system that collects data from surface surveillance systems, hydrological monitoring networks, balloon-borne instruments, Doppler radars, aircraft sensors, and other sources. The NOAA Surface Weather Program will transition MADIS into operations as they develop the National Surface Weather Observing System (NSWOS). The NSWOS will ultimately include ESS data collected through the *Clarus* System. The NSWOS will integrate disparate observations systems and formats to meet the needs of various user communities, including transportation agencies.

4.1 Environmental Sensor Stations (ESS) and Road Weather Information Systems (RWIS)

An Environmental Sensor Station (ESS) is a roadway location with one or more fixed sensors measuring atmospheric, pavement and/or water level conditions. These stations are typically deployed as field components of RWIS. Data collected from environmental sensors in the field are stored onsite in a Remote Processing Unit (RPU) located in a cabinet. In addition to the RPU, cabinets typically house power supply and battery back-up devices. Atmospheric data include air temperature and humidity, visibility distance, wind speed and direction, precipitation type and rate, tornado or waterspout occurrence, lightning, storm cell location and track, as well as air quality. Pavement data include pavement temperature, pavement freeze point, pavement condition (e.g., wet, icy, flooded), pavement chemical concentration, and subsurface conditions (e.g., soil temperature). Water level data include tide levels (e.g., hurricane storm surge) as well as stream, river, and lake levels near roads.



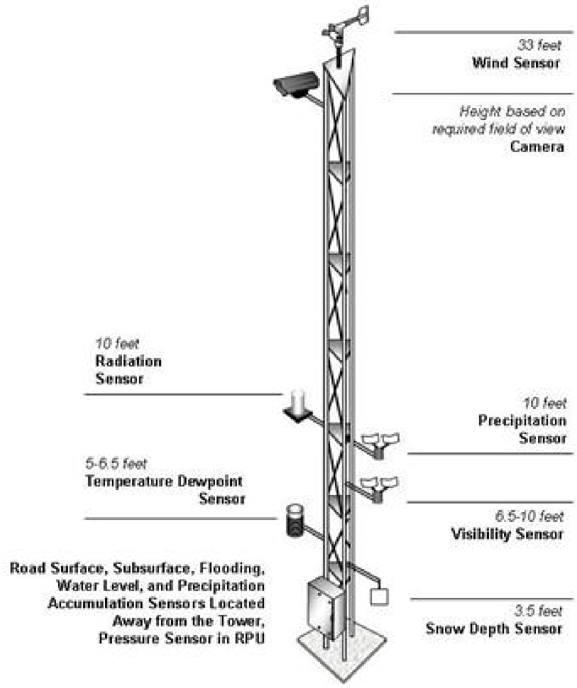


Figure – ESS Operational Applications

Figure – Environmental Sensor Station

As shown on the National ESS Map, there are over 2,400 ESS owned by state transportation agencies. Most of these stations, over 2,000, are field components of Road Weather Information Systems (RWIS), which are typically used to support winter road maintenance activities. The other stations are deployed for various applications including traffic management, flood monitoring, and aviation. Central RWIS hardware and software collect field data from numerous ESS, process data to support various operational applications, and display or disseminate road weather data in a format that can be easily interpreted by a manager.

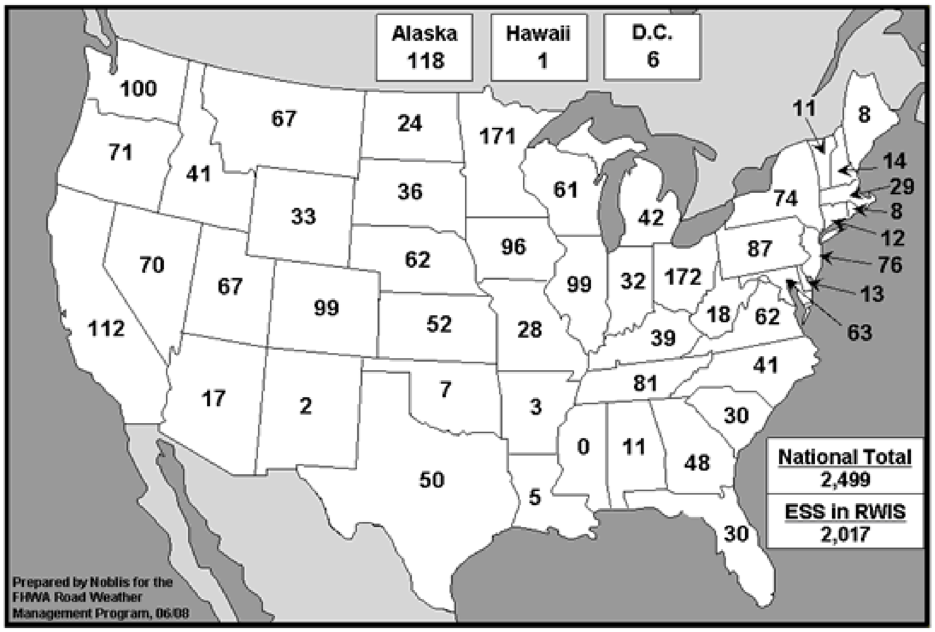


Figure – National Environmental Sensor Station Map

4.2 Mobile Sensing

Mobile sensors are deployed to observe environmental conditions from any type of vehicle. Vehicle-mounted sensor systems can be utilized to sense pavement conditions (e.g., temperature, friction) and atmospheric conditions (e.g., air temperature), which are transmitted to central locations via Automated Vehicle Location (AVL) and Global Positioning System (GPS) technologies. An important mobile sensing application is thermal mapping of road segments. This technique provides pavement temperature profiles that can be used both to select ESS sites and to spatially predict temperatures based upon ESS data. Transportation agencies in Iowa, Michigan, and Minnesota have partnered to deploy and evaluate advanced maintenance vehicles equipped with mobile environmental sensors, including a pavement freeze point sensor and a friction measuring device. For more information, visit the web site for the Concept Highway Maintenance Vehicle project which is now in its fifth phase (http://www.ctre.iastate.edu/research/conceptv/index.htm).

IntelliDrive[SM] is a suite of technologies and applications that use wireless communications to provide connectivity that can deliver transformational safety, mobility, and environmental improvements in surface transportation. IntelliDrive[SM] applications provide connectivity with and among vehicles, between vehicles and the roadway infrastructure. among vehicles, infrastructure, and wireless devices (consumer electronics, such as cell phones and PDAs) that are carried by drivers, pedestrians, and bicyclists. This will involve the collection of various data types from passenger vehicles, including weather and pavement condition data, for multiple applications.

As input to the IntelliDrive^{SM} Initiative, the FHWA Road Weather Management Program has worked to promote three weather-related applications: Winter Maintenance, Weather Information for Traveler Notification, and Weather Information for Improved Forecasting. The Winter Maintenance application will integrate traditional sources of road weather data with sensor data from IntelliDrive^{SM}-equipped vehicles (both private vehicles and maintenance vehicles) to support road treatment decisions, and to communicate treatment information to maintenance vehicles in an expeditious manner. The Weather Information for Traveler Notification application will gather probe data generated by IntelliDrive^{SM} vehicles, analyze and integrate those observations with weather data from traditional sources, develop route-specific weather reports and forecasts, and disseminate information over the IntelliDrive^{SM} network to areas impacted by weather events. The Weather Information for Improved Forecasting application will focus on the use of probe data to improve the weather forecasting process. It will not provide weather-related information back to the vehicle. A video was prepared to highlight the opportunities emerging in support of Road Weather Management found at the following link provided on the IntelliDrive^{SM} site as well as linked to from the FHWA Road Weather Management page: http://www.intellidriveusa.org/library/videos.php as a News Clip.

The program has also sponsored preliminary mobile sensing research. Mitretek Systems (now Noblis) performed foundational research on the characteristics and the feasibility of using vehicles as meteorological sensor platforms. Vehicles were equipped with air temperature sensors in the front bumper, near the engine air intake cowling, and in the rear bumper. More information on this research can be found in a presentation on *Vehicles as Mobile Meteorological Platforms: Introductory IntelliDrive^{SM} Research* (http://www.clarusinitiative.org/documents/ICC5/CL Session 6 Stern Mitretek Vehicle Study.ppt). The National Center for Atmospheric Research (NCAR) conducted a feasibility study to explore and assess the utility of using data from vehicles to improve surface transportation weather observations and predictions and road condition hazard analyses and predictions. Researchers identified technical issues and challenges related to the use of vehicle data, and provided recommendations that will help ensure successful exploitation of vehicle probe data in weather applications. Study results are summarized in a presentation on *The Feasibility of Using Vehicles as Probes* (http://www.clarusinitiative.org/documents/ICC5/CL Session 6 Petty Clarus_ICC_VII_pres_21Sep2007kpetty.ppt) and in a report titled *Weather Applications and Products Enabled through VII: Feasibility and Concept Development Study* (http://ops.fhwa.dot.gov/publications/viirpt/index.htm).

Private sector real-time traffic information is becoming increasingly available on the extensive highway and freeway network throughout the country as well as major arterial routes in many urbanized areas. New approaches are to use GPS location data to generate corridor speeds. This traffic data could be purchased or arranged through an agreement with the private sector data provider to provide real-time traffic information along I-80. The I-95 Coalition states purchased INRIX data along the entire I-95 corridor to provide real-time traffic speeds and travel times statewide in New Jersey, South Carolina, and North Carolina. The I-95 Corridor Coalition has entered into a partnership with the USDOT under the SAFETRIP-21 program to support corridor-wide traveler information and road conditions reporting. Other private sector data providers involved in partnerships for providing data to the public sector include NAVTEQ, TrafficCast, Google, and others.

It will be important for Coalition member states to evaluate the potential use of private sector data for this corridors purpose.

4.3 Remote Sensing

In remote sensing, a detector is located at a significant distance from a target. The sensor can be mounted on unmanned aerial vehicles or part of a radar or satellite system used for surveillance of meteorological and oceanographic conditions. Images and observations from remote sensors are used for weather monitoring and forecasting from local to global scales. Remote sensing is used for quantitatively measuring atmospheric temperature and wind patterns, monitoring advancing fronts and storms (e.g., hurricanes, blizzards), imaging of water (i.e., oceans, lakes, rivers, soil moisture, vapor in the air, clouds, snow cover), as well as estimating runoff and flood potential from thawing.

As part of the *Clarus* Initiative, the FHWA has sponsored foundational research to assess the feasibility of obtaining video imagery from State DOT Closed Circuit Television (CCTV) cameras to determine if new surface transportation-related elements can be derived. Researchers at the MIT Lincoln Laboratory have created an algorithm that uses visible camera imagery, with automated orientation, to estimate roadway visibility. More information on this research can be found in the Automated Extraction of Weather Variables from Camera Imagery (http://www.ctre.iastate.edu/pubs/midcon2005/HallowellImagery.pdf) report.

California DOT Motorist Warning System

Freeways in the Stockton-Manteca area of San Joaquin County, California are prone to low visibility conditions. Visibility is reduced by wind-blown dust in the summer and dense, localized fog in the winter. In the past low visibility has contributed to numerous chain-reaction collisions in the San Joaquin Valley. To improve roadway safety on southbound Interstate 5 and westbound State Route 120, the California Department of Transportation (DOT)—also known as Caltrans—implemented an automated system to warn motorists of driving hazards.

System Components: Traffic and weather data are collected from 36 vehicle detection sites and nine Environmental Sensor Stations (ESS) deployed along the freeways, as shown in the figure. Detection sites are comprised of paired inductive loop detectors and Caltrans Type 170 controllers, which run software with speed measurement algorithms. Each ESS includes a rain gauge, a forward-scatter visibility sensor, wind speed and direction sensors, a relative humidity sensor, a thermometer, a barometer, and a remote processing unit. Traffic and environmental data are transmitted from the field to a networked computer system in the Stockton Traffic Management Center (TMC) via dedicated, leased telephone lines. The central computer system automatically displays advisories on nine roadside Dynamic Message Signs (DMS).


California DOT ESS

System Operations: Three central computers control operation of the motorist warning system. A meteorological monitoring computer records and displays ESS data. A traffic monitoring computer uses a program developed by Caltrans operations staff to record, process, and display traffic volume and speed data. Through interfaces with the monitoring computers, a DMS control computer accesses environmental and average speed data to assess driving conditions. Based upon established thresholds for vehicle speed, visibility distance, and wind speed; proprietary control software automatically selects and displays warnings on DMS as shown in the table. TMC operators also have the capability to manually override messages selected by the system.

California DOT Motorist Warning System Messages

Conditions	Displayed Message
Average speed between 11 and 35 mph (56.3 kph)	"SLOW TRAFFIC AHEAD"
Average speed less than 11 mph (17.7 kph)	"STOPPED TRAFFIC AHEAD"
Visibility distance between 200 and 500 feet (152.4 meters)	"FOGGY CONDITIONS AHEAD"
Visibility distance less than 200 feet (61.0 meters)	"DENSE FOG AHEAD"
Wind speed greater than 35 mph	"HIGH WIND WARNING"

When visibility falls below 200 feet these advisory strategies are supplemented by vehicle guidance operations carried out by the Department of Emergency Management. On major freeway routes, California Highway Patrol officers use flashing amber lights atop patrol vehicles to group traffic into platoons, which are lead at a safe pace (typically 50 mph or 80.4 kph) through areas with low visibility.

Transportation Outcome: The motorist warning system improved highway safety by significantly reducing the frequency of low-visibility crashes. Nineteen fog-related crashes occurred in the four-year period before the system was deployed. Since the system was activated in November 1996, there have been no fog-related crashes. Vehicle guidance operations improve also safety by minimizing crash risk.

Implementation Issues: Designers considered local conditions and potential safety benefits to assess the feasibility of a warning system. Limited sight distances, converging traffic patterns, and frequent low visibility events factored into the decision to deploy a motorist warning system on selected freeways. These factors also guided development of system requirements. The system had to have the capability to continuously and automatically collect, process, and display information. System designers examined historical crash data to establish a baseline for evaluation of the motorist warning system.

System components include commercially available products as well as hardware and software developed by Caltrans operations staff. The meteorological monitoring system was procured as a turnkey solution. The ESS manufacturer installed field devices, the monitoring computer, and proprietary processing software. Caltrans personnel designed and installed the traffic monitoring and DMS control components using standardized and commercial off-the-shelf products to minimize procurement costs and deployment time. Because display technologies had to be visible in adverse conditions, incandescent DMS were selected based upon their readability in low visibility conditions. After system elements were procured, installed, and calibrated operational procedures were developed, maintenance schedules and contracts were arranged, and traffic operations personnel were trained.

Future system expansion was taken into account by designers. Anticipated enhancements include the integration of the monitoring and control computers into a single workstation, incorporation of a Closed Circuit Television surveillance system for visual verification of roadway conditions, inclusion of a Highway Advisory Radio system to supplement visual warning messages, and testing of Variable Speed Limits and pavement lights. An interface to the California Highway Patrol information system is also expected.

Contact(s):

- Clint Gregory, Caltrans District 10, Electrical Systems Branch Chief, 209-948-7449, clint_gregory@dot.ca.gov.
- Ted Montez, California Highway Patrol, Public Information Officer, 209-943-8666, tmontez@chp.ca.gov.

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Keywords: fog, dust, wind, visibility, motorist warning system, freeway management, traffic management, emergency management, law enforcement, advisory strategy, traveler information, vehicle guidance, control strategy, vehicle detection, environmental sensor station (ESS), dynamic message signs (DMS), safety

Minnesota DOT Access Control

Since 1996 several Minnesota Department of Transportation (DOT) maintenance districts have worked with the Minnesota State Patrol and county sheriffs to direct traffic off of freeways and to restrict freeway access at ramps when winter storms create unsafe travel conditions. After maintenance vehicles have cleared snow and ice, freeways are reopened to traffic.

System Components: Two types of gates are used to restrict freeway access. One maintenance district has installed gate arms that are positioned on the side of the road and swing into place when needed. These arms have amber lights. Other districts deployed upright gate arms, with red lights, that are lowered into position. Static fold-down warning signs are located in advance of gates to notify motorists of freeway closures.

System Operations: Traffic and maintenance managers consider several variables to identify threats to highway operations. Weather parameters include winter storm duration and severity (i.e., snowfall rate), and visibility. Pavement condition, time of day, day of the week, seasonal travel patterns, and the capacity of towns to accommodate diverted motorists are transportation system factors. Threat information is used to determine closure locations and times.

When a threat is identified traffic and emergency management personnel execute a systematic, coordinated plan to divert traffic off of freeways with mainline gates and prohibit freeway access using ramp gates. DOT personnel travel to gate locations to open warning signs and activate gate arm lights. As shown in the figure, gate arms are then positioned in travel lanes to alert drivers that the freeway is closed. During closure and reopening activities, uniformed law enforcement personnel staff gate locations with patrol vehicles to prevent motorists from interfering with clearing operations.

Minnesota DOT
Ramp Gates and Warning Signs

Transportation Outcome(s): During a severe snowstorm on November 11, 1998 a 50-mile (80.4-kilometer) section of Interstate 90 was closed, while 59 miles (94.9 kilometers) of US Highway 75 remained open. Plows made four passes on Interstate 90 and ten passes on Highway 75 to clear the pavement of snow and ice. The freeways were reopened when the pavement was 95 percent clear. Because Highway 75 was open to traffic, significant snow compaction occurred on this roadway. Delay on Interstate 90 was minimized, as it was cleared four hours before Highway 75. As shown in the following table, over 24 dollars per lane mile were expended on Highway 75, while it cost less than 20 dollars per lane mile to clear Interstate 90.

Minnesota DOT Access Control and Maintenance Costs

	US Highway 75 (Open to Traffic)	**Interstate 90** (Access Restricted)	**Percent Difference**
Number of Plow Passes	10	4	60%
Total Miles Plowed	590	200	66%
Labor Hours per lane mile	0.41	0.38	7%
Labor Costs per lane mile	$9.98	$9.08	9%
Material Costs per lane mile	$4.59	$4.50	2%
Equipment Costs per lane mile	$9.54	$6.14	36%
Total Costs per lane mile	**$24.11**	**$19.72**	**18%**

The DOT conducted a study of Interstate 90 closures in 1999. Analysis revealed that roughly 80 crashes per year were related to poor road conditions on the freeway. Study results also confirmed that access control operations enhanced mobility by reducing closure time and associated vehicle delay. Examination of this control strategy during a single storm event and over a six-month period indicated that productivity, mobility, and safety were improved.

Implementation Issues: The DOT contracted with a consulting firm to analyze the costs and benefits of deploying gate arms for access control. The consultant used historical operations and crash data to calculate benefits associated with reductions in travel time delay and crash frequency. After deciding to implement gate arms based upon the benefit/cost analysis, the DOT consulted agencies in North and South Dakota. An assessment of gates used in the Dakotas found that snowdrifts could block swinging gates necessitating shoveling before they could be positioned in the road. The upright gates also had disadvantages. In some cases, the pulley mechanism failed causing the gate arm to slam down unexpectedly. Individual maintenance districts selected the type of arm most appropriate for their operations. Ice and high winds occasionally interfered with the opening of warning signs.

The DOT plans to test remote operation of gates and Closed Circuit Television surveillance at one interchange. Remote monitoring and control via a secure web site will be tested during the 2002/2003 winter season.

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- Farideh Amiri, Minnesota DOT, ITS Project Manager, 651-296-8602, farideh.amiri@dot.state.mn.us.

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Keywords: winter storm, snow, ice, access control, freeway management, treatment strategy, winter maintenance, control strategy, traffic control, law enforcement, advisory strategy, motorist warning system, institutional issues, gates, maintenance vehicle, safety, mobility, productivity

Utah DOT Low Visibility Warning System

Due to high traffic volumes and local conditions conducive to dense fog formation, the Utah Department of Transportation (DOT) deployed a low visibility warning system on Interstate 215 to notify motorists of safe travel speeds and to promote more uniform traffic flow. The warning system was installed on a low-lying, two-mile (three-kilometer) highway segment above the Jordan River in Salt Lake City where several multi-vehicle, fog-related crashes have occurred. In 1988 there was a 66-vehicle crash and in 1991 ten crashes, with three fatalities, occurred on one day.

System Components: Four forward-scatter visibility sensors and six vehicle detection sites are installed on the freeway to collect data on prevailing conditions. Visibility distance is measured in real-time and inductive loop detectors record the speed, length, and lane of each vehicle. Through Ultra-High Frequency radio modems these data are transmitted to a central computer system that records field data in a database, processes field data, and posts advisories on two roadside Dynamic Message Signs (DMS).

System Operations: The central computer identifies threats by using visibility distance, vehicle speed, and vehicle classification data in a weighted average algorithm to determine when conditions warrant motorist warnings. When visibility distance falls below 820 feet (250 meters), the computer automatically displays a warning on DMS. Based on stopping sight distances, safe travel speeds are posted on DMS when visibility is less than 656 feet (200 meters). Messages displayed for various visibility ranges are shown in the table below.

Utah DOT Low Visibility Warning System Messages

Visibility Conditions	Displayed Messages
656 to 820 feet (200 to 250 meters)	"FOG AHEAD"
492 to 656 feet (150 to 200 meters)	"DENSE FOG" alternating with "ADVISE 50 MPH"
328 to 492 feet (100 to 150 meters)	"DENSE FOG" alternating with "ADVISE 40 MPH"
197 to 328 feet (60 to 100 meters)	"DENSE FOG" alternating with "ADVISE 30 MPH"
Less than 197 feet (60 meters)	"DENSE FOG" alternating with "ADVISE 25 MPH"

Transportation Outcome: An evaluation of the warning system indicated that overly cautious drivers sped up when advisory information was displayed, resulting in a 15 percent increase in average speed from 54 to 62 mph (86.8 to 99.7 kph). This increase caused a 22 percent decrease in speed variance from 9.5 to 7.4 mph (15.3 to 11.9 kph). Reducing speed variance enhanced mobility and safety by promoting more uniform traffic flow and minimizing the risk of initial, secondary, and multi-vehicle crashes.

Implementation Issues: In 1993 DOT researchers responded to a federal solicitation to prototype a low visibility warning system. The DOT contracted with a consultant in 1994 to design and install the system on Interstate 215 due to recurring fog. During winter 1995/1996 the DOT collected visibility distance and traffic data before DMS were deployed to assess driver behavior in fog without advisories. By the end of 1997 field, central, and communication equipment was installed, calibrated, and integrated. DMS calibration and verification was carried out with the assistance of the Utah Highway Patrol.

The system was operational by winter 1999/2000 and traffic managers began collecting traffic speed data, vehicle classification data, visibility data, as well as displayed messages. The DOT partnered with the University of Utah to conduct an evaluation of system effectiveness. The University analyzed traffic speeds by time-of-day, lane and direction, vehicle classification, and visibility distance with data collected over four winter seasons. Based on positive results, it was recommended that speed and pavement condition data be incorporated into control logic, that the warning system be integrated with the DOT's Advanced Traffic Management System, and that further evaluation be conducted. The DOT plans to enhance the system by deploying an Environmental Sensor Station to detect weather and pavement conditions, upgrading the DMS, and replacing the radio communication system with fiber optic cable.

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- Sam Sherman, Utah DOT, ITS Division, 801-965-4438, sshermam@utah.gov

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Keywords: fog, low visibility warning system, freeway management, traffic management, control strategy, speed management, advisory strategy, motorist warning system, traveler information, vehicle detection, dynamic message sign (DMS), driver behavior, safety, mobility

Utah DOT Fog Dispersal Operations

In northern Utah widespread, super-cooled fog (i.e., less than 32 degrees F) can persist in mountain valleys for weeks. Utah Department of Transportation (DOT) maintenance personnel use liquid carbon dioxide to disperse fog and improve visibility along segments of Interstates 15, 70, 80, and 84; US Highways 40, 89, and 91; as well as secondary roads in Cache Valley and Bear Lake Valley. This treatment strategy includes the application of anti-icing chemicals as fog is dispersed to prevent moisture from freezing on the pavement.

System Components: Fog dispersal equipment, comprised of commercially available products, is installed on roughly 70 maintenance vehicles or 15 percent of the fleet. As shown in the figure, each truck is equipped with a compressed gas cylinder, a manual valve assembly, mounting brackets, copper pipe, and a dispensing nozzle. Each cylinder holds liquid carbon dioxide at a pressure of 2,000 pounds per square inch.

System Operations: Before vehicles leave the maintenance yard for normal patrol duties, the cylinder and valve assembly are attached. Dispensers are turned on when maintenance vehicles leave the yard and turned off when they return. As the vehicles travel through super-cooled fog, very small amounts of liquid carbon dioxide are sprayed into the slipstream of the truck. The carbon dioxide quickly evaporates removing heat from water droplets in the fog. The droplets form ice crystals and precipitate as fine snow or ice.

Utah DOT Maintenance Vehicle with Fog Dispersal Equipment

To prevent the precipitate from freezing on the road surface, anti-icing chemicals are simultaneously applied. If the air temperature is below 20 degrees F (-6.7 degrees C), common road salt is prewetted with liquid magnesium chloride and applied to pavements. Road salt or sodium chloride brine is spread when the air temperature is above 20 degrees F.

Transportation Outcome: The fog dispersal treatment strategy improves roadway mobility and safety. This strategy can increase visibility distance behind the maintenance vehicle from 33 feet (10 meters) to 1,640 feet (500 meters) in less than 30 minutes. The treatment remains effective for 30 minutes to 4 hours, depending upon air temperature and wind speed. Improved visibility has significantly reduced rear-end crashes into maintenance vehicles, enhancing the safety of DOT personnel and the public.

Implementation Issues: In 1990 the DOT's Research Division sponsored a University of Utah research grant to investigate fog control at a bridge location. During the study university researchers noticed that a tunnel of clear visibility formed in the fog as carbon dioxide was dispensed. In 1992 DOT and university researchers developed a prototype with customized hardware components and began the field testing of mobile fog dispersal techniques. The Research Division published field trial results in 1993.

Based upon recommendations in the field trial report and lessons learned from anti-icing operations near Salt Lake International Airport, maintenance personnel configured a truck with fog dispersal equipment composed of commercial-off-the-shelf products. This configuration was more cost effective than the customized configuration developed by the University, which was prohibitively expensive.

Before fog dispersal equipment was deployed in 2000, the DOT developed a two-hour training course to ensure employee safety when working with compressed liquid carbon dioxide. Training course topics included oxygen-displacement properties of the chemical, chemical handling techniques, and operation of the high-pressure dispenser.

Contact(s):

- Lynn J. Bernhard, Utah DOT Maintenance Planning Division, Methods Engineer, 801-964-4597, lynnbernhard@utah.gov.
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Keywords: fog, visibility, air temperature, wind, fog dispersal operations, freeway management, winter maintenance, treatment strategy, maintenance vehicle, chemicals, anti-icing/deicing, crashes, safety, mobility

Idaho DOT Anti-Icing/Deicing Operations

In 1996 maintenance managers with the Idaho Department of Transportation (DOT) began an anti-icing program on a 29-mile (47-kilometer) section of US Route 12. This highway segment is located in a deep canyon and is highly prone to snowfall and pavement frost (i.e., black ice) due to sharp curves and shaded areas. An anti-icing chemical is applied to road surfaces as an alternative to spreading high quantities of abrasives. Abrasives are thrown to the roadside by passing vehicles and only improve roadway traction temporarily.

System Components: Winter maintenance managers modified maintenance vehicles for use in anti-icing operations and installed chemical storage tanks. Trucks with 1,000-gallon (3,785-liter) and 1,500-gallon (5,678-liter) tanks were equipped with spray controls to dispense liquid magnesium chloride. A chemical storage facility with two 6,900-gallon (26,117-liter) storage tanks and an electric pump for chemical circulation and truck loading was located in the Orofino maintenance yard.

**Idaho DOT
Maintenance Vehicles**

**Idaho DOT
Chemical Storage Tanks**

System Operations: Maintenance managers utilize the Internet to access weather forecast data and identify threatening winter storms or frost events. When an impending threat is predicted, maintenance vehicles are deployed to spray small amounts of the anti-icing chemical on road surfaces before snowfall begins or frost forms. Chemical application rates vary from ten to 50 gallons (37.9 to 189.3 liters) per lane mile, depending on the nature and magnitude of the threat. Maintenance crews regularly check four “indicator areas” along the highway to determine when frost on shoulder lanes begins to migrate into travel lanes. The status of these areas indicates that the road should be retreated to ensure that chemical concentrations are high enough to prevent freezing.

Transportation Outcome: To assess the effectiveness of anti-icing operations, winter road maintenance activities were analyzed for five years prior to the anti-icing program and for three years after implementation. Annual averages of abrasive quantities, labor hours, and winter crashes are shown in the table.

Idaho DOT Winter Maintenance Performance Measures
(Annual Averages)

	1992 to 1997 (Without Anti-Icing)	1997 to 2000 (With Anti-Icing)	Percent Reduction
Abrasive Quantities	1,929 cubic yards (1,475 cubic meters)	323 cubic yards (247 cubic meters)	83%
Labor Hours	650	248	62%
Number of Crashes	16.2	2.7	83%

Mobility, productivity, and safety enhancements resulted from the anti-icing treatment strategy. Mobility was improved, as a single application of magnesium chloride was typically effective at improving traction for three to seven days—depending on precipitation, pavement temperature, and humidity. Faster clearing of snow and ice reduced operation costs and enhanced productivity. Safety improvements were realized by reducing the frequency of wintertime crashes.

Implementation Issues: Maintenance managers selected the US Route 12 segment for their anti-icing pilot program due to the high crash rate and high maintenance costs. Relatively mild winter temperatures, hazardous winter road conditions, and moderate traffic volumes also made this roadway a good candidate for anti-icing operations.

Other Idaho DOT maintenance districts had successful anti-icing programs. By consulting other districts and assessing existing vehicles, managers developed treatment equipment requirements. Trucks, previously used to spray weed-killing and other chemicals, were modified to dispense liquid magnesium chloride. After configuring the treatment equipment, crews were trained in all aspects of anti-icing procedures. They learned about various anti-icing chemicals and their properties, chemical application criteria and rates, equipment operation, and progress tracking. As a result of the successful pilot program, anti-icing was expanded to other highways in District 2 and throughout the state.

Contact(s):
- Bryon Breen, Assistant Maintenance Engineer, 208-334-8417, bbreen@itd.state.id.us.

Reference(s):

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Keywords: snow, ice, winter storm, anti-icing/deicing operations, freeway management, winter maintenance, treatment strategy, internet/web site, forecasts, weather information, maintenance vehicle, chemicals, crashes, mobility, productivity, safety

City of New York, New York Anti-Icing/Deicing System

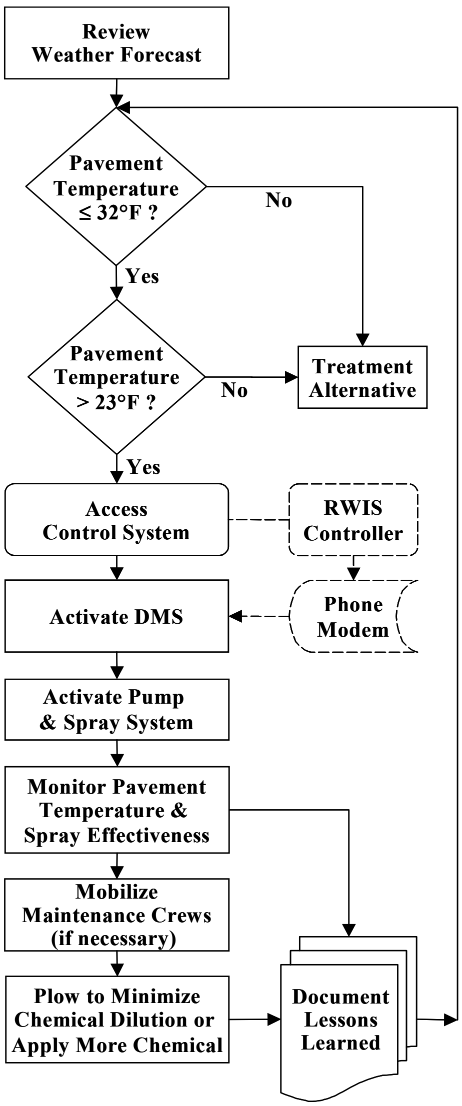
The New York City Department of Transportation (DOT) developed a fixed anti-icing system prototype for a portion of the Brooklyn Bridge. The system sprays an anti-icing chemical on the bridge deck when adverse weather conditions are observed. Anti-icing reduces the need to spread road salt, which has contributed to corrosion of bridge structures.

System Components: The anti-icing system is comprised of a control system, a chemical storage tank containing liquid potassium acetate, a pump, a network of PVC pipes installed in roadside barriers, check valves with an in-line filtration system, 50 barrier-mounted spray nozzles, and a Dynamic Message Sign (DMS). The DMS displays warnings to alert motorists during spray operations. A Closed Circuit Television (CCTV) camera allows operators to visually monitor the anti-icing system.

Each self-cleaning nozzle delivers up to three gallons (11.4 liters) of chemical per minute at a 15-degree spray angle. This angle minimizes misting that could reduce visibility. Two nozzle configurations were implemented to investigate different spray characteristics. On both sides of one bridge section, nozzles were installed 20 feet (6.1 meters) apart for simultaneous spraying. On another section, sequential spray nozzles were mounted on only one side of the bridge.

System Operations: System operators consult television and radio weather forecasts to make road treatment decisions. When anti-icing is deemed necessary, "ANTI-ICING SPRAY IN PROGRESS" is posted on the DMS and the system is manually activated to spray potassium acetate on the pavement for two to three seconds, delivering a half-gallon per 1,000 square feet (1.9 liters per 92.9 square meters).

Operators then review forecasts and view CCTV video images to monitor weather and pavement conditions. If there is a 60 percent or greater chance of precipitation and pavement temperatures are predicted to be lower than the air temperature, maintenance crews are mobilized to supplement anti-icing operations with plowing to remove snow and ice. The operational sequence is depicted in the flowchart.



City of New York, NY Anti-icing/Deicing System Operational Sequence

Transportation Outcome: An analysis of maintenance operations found that bridge sections treated with the anti-icing system had a higher level of service than segments treated by snowplows and truck-mounted chemical sprayers. Road segments treated by the anti-icing system have less snow accumulation than sections treated conventionally. Pavement conditions during a snow event in January 1999 are depicted in the figures below.

Evaluation results indicated that the anti-icing system improves roadway mobility and safety in inclement weather. The system was most effective when chemical applications were initiated at the beginning of weather events. If potassium acetate was sprayed more than an hour before a storm, vehicle tires dispersed the chemical necessitating subsequent applications. The system also improves productivity by extending the life of bridges and minimizing treatment costs associated with mobilizing maintenance crews, preparing equipment, and traveling to treatment sites on congested roads.

City of New York, NY Bridge Section Treated with Anti-Icing System

Implementation Issues: Corroded steel grid members were observed in the concrete bridge deck during routine repaving operations in the summer of 1998. The anti-icing system prototype was designed to apply a less corrosive chemical than salt and to minimize the need for road infrastructure repairs. During system design and testing various chemical delivery configurations were examined to determine the appropriate spray pattern, angle, and pressure. Due to concerns about bridge deck integrity, nozzles were barrier-mounted rather than embedded in the road surface.

City of New York, NY Bridge Section Treated with Truck-Mounted Sprayer

System performance was evaluated over the 1998/1999, 1999/2000, and 2000/2001 winter seasons. The evaluation included an assessment of the capabilities and reliability of system components, documentation of spray area coverage, a review of road treatment procedures and results, and a cost analysis comparing the anti-icing system to conventional treatment techniques.

The DOT would like to expand the anti-icing system by integrating a Road Weather Information System (RWIS) with the control system, the CCTV camera, and the DMS to improve treatment decision-making. A wireless or fiber optic cable communication network is envisioned for connectivity of these elements. Deployment of the system on the entire Brooklyn Bridge and on other local bridges is also anticipated.

Contact(s):

- Brandon Ward, New York City DOT, Project Manager, 212-788-1720, bward2@dot.nyc.gov.

Reference(s):

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Keywords: snow, ice, winter storm, anti-icing/deicing system, freeway management, winter maintenance, bridge, forecasts, treatment strategy, chemicals, maintenance vehicle, air temperature, pavement temperature, pavement condition, traveler information, advisory strategy, dynamic message sign (DMS), closed circuit television (CCTV), safety, mobility, productivity

Florida DOT Motorist Warning System

The tropical climate in south Florida typically causes heavy rainfall in the afternoon. A Florida Department of Transportation (DOT) study of the Florida Turnpike/Interstate 595 interchange found that 69 percent of crashes on a two-lane, exit ramp occurred when the pavement was wet and that only 44 percent of these wet-pavement crashes happened when it was raining. The wet-pavement crash rate on this ramp was three times higher than the national average and nearly four times greater than the statewide average. To demonstrate how advanced warning of the safe travel speed under wet pavement conditions can reduce crash risk, the DOT installed an automated motorist warning system on the ramp, which has a sharp curve and an upgrade.

System Components: As shown in the figure, a sensor embedded in the road surface was used to monitor pavement condition (i.e., dry or wet). On a pole adjacent to the ramp, a microwave vehicle detector was installed to record traffic volume and vehicle speed, and a precipitation sensor was mounted to verify rainfall events. A pole-mounted enclosure housed a remote processing unit (RPU), which was hard-wired to flashing beacons atop static speed limit signs. A dedicated telephone line was also connected to the RPU to facilitate data retrieval from an Internet server in the turnpike operations center located in Pompano Beach.

Florida DOT Pavement Sensor

System Operations: The RPU collected, processed, and stored traffic and pavement data from the sensors. When pavement moisture was detected, the RPU activated the flashing beacons to alert motorists that speeds should not exceed the posted limit of 35 mph (56.3 kph).

Transportation Outcome: The warning system improved safety by reducing vehicle speeds and promoting more uniform traffic flow when the ramp was wet. In light rain conditions, the 85th percentile speed decreased by eight percent from 49 to 45 mph (78.8 to 72.4 kph). During heavy rain, there was a 20 percent decline in 85th percentile speed from 49 to 39 mph (78.8 to 62.7 kph). Speed variance was reduced from 6.7 to 5.7 mph (10.8 to 9.2 kph) in light rain and from 6.1 to 5.6 mph (9.8 to 9.0 kph) in heavy rain. Thus, speed variance decreased by eight to 15 percent, minimizing crash risk. Four crashes occurred during the first week of warning system activation. Three happened when the pavement was wet and one occurred during rainfall. After this initial week, there were no reported crashes the during nine-week evaluation period.

Implementation Issues: The DOT evaluated the geometry, road surface conditions, and crash history of the ramp, which had the highest travel speeds and the highest crash rate of all the ramps in the interchange. It was concluded that wet pavement and excessive travel speeds were the primary factors contributing to run-off-the-road crashes that occurred at the beginning of the sharp ramp curve. These conditions warranted the development and demonstration of a motorist warning system. The demonstration project was a joint effort of the Florida DOT, the University of South Florida, and a private vendor.

The DOT erected a 25-foot (7.6-meter) equipment mounting pole 8 feet (2.4 meters) from the edge of the travel lane, installed flashing beacons on two existing ramp signs, and arranged power and telephone service connections. The pole was installed approximately 180 feet (55 meters) in advance of the speed limit signs. The vendor furnished and installed field sensors, the RPU, and the Internet server. The pavement sensor was installed at the lowest elevation point of the ramp.

After installation, the project partners verified the accuracy and reliability of system components. Vehicle detector data accuracy was validated by comparing speed measurements with those from a hand-held radar gun. The private vendor calibrated the dry-wet threshold of the pavement sensor. Beacon activation by the RPU and field data downloading to the turnpike operations center were successfully tested. Through the server, the University retrieved pavement condition, speed, and volume data at one-minute intervals to evaluate system performance before and after activation.

Contact(s):

- Michael Pietrzyk, University of South Florida, Center for Urban Transportation Research (CUTR), 813-974-9815, pietrzyk@cutr.eng.usf.edu.

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Keywords: rain, pavement condition, pavement friction, motorist warning system, freeway management, traffic management, advisory strategy, pavement sensor, vehicle detection, speed, driver behavior, crashes, safety

Michigan Maintenance Vehicle Management System

Four road maintenance agencies and a regional transit authority worked together to implement a management system for maintenance vehicles in southeastern Michigan. Partners include the City of Detroit Department of Public Works, the Road Commission for Oakland County, the Road Commission of Macomb County, the Wayne County Department of Public Services, and the Suburban Mobility Authority for Regional Transportation. The four agencies, who maintain over 15,000 road miles in the region, formed the Southeast Michigan Snow and Ice Management (SEMSIM) partnership in 1998.

System Components: The maintenance vehicle management system consists of snowplow systems, a communication system, and central systems. Snowplow systems include sensors, automated controls, and in-vehicle devices. Environmental sensors are mounted on snowplows to record air temperature and pavement temperature. Vehicle status sensors monitor the position of each snowplow (i.e., location, direction and speed), plow position (i.e., up/down), and material application (i.e., salt on/off, application rate). Each maintenance vehicle, shown in the figure, has automated application controls. Computerized salt spreaders automatically adjust the application rate based upon the speed of the snowplow.

Michigan Maintenance Vehicle

In-vehicle devices integrate display, text messaging, and data communication capabilities. These devices include interfaces to snowplow systems and Global Positioning System receivers, which are used for automated vehicle location. The communication backbone is owned and operated by the regional transit authority. The authority's 900 MHz radio communication system transmits environmental and status data from in-vehicle devices to the transit management center. A Local Area Network, an Integrated Services Digital Network and multiple dial-up telephone lines are used to transmit data from the management center to central computers accessed by both maintenance managers and transit dispatchers.

System Operations: Central computers display a map-based interface that maintenance managers view to identify weather threats, track snowplow locations, monitor treatment activities, and plan route diversions if necessary. Each maintenance vehicle appears on the map with a color-coded trace indicating where plows have been and what treatment has been applied (e.g., spreading salt, plow down). Text messages from managers, such as route assignments, may be displayed to drivers on the in-vehicle devices. With these devices, drivers can send messages to managers, as well as view temperature measurements and salt gauge.

The maintenance vehicle management system can be used to plan treatment strategies, monitor real-time operations, and conduct post-event analysis. Post-event analysis provides maintenance managers with statistics (e.g., driver hours, truck miles, material applied) that can help reduce the costs of future winter maintenance operations. Environmental data from the plows also serves as decision support for transit dispatchers, who utilize this information to make scheduling and routing decisions during winter storms.

Transportation Outcome: SEMSIM partners have improved agency productivity by implementing the maintenance vehicle management system. With the system, managers can identify the most efficient treatment routes, reduce equipment costs, and share resources. Automated salt application controls minimize material costs. The system also improves roadway safety and mobility by allowing the partners to assess changing weather conditions and quickly respond to effectively control snow and ice.

Although each agency had different types of snowplows, with dissimilar equipment, and diverse operational procedures, this project has facilitated interagency communication that benefits both the public and partners. The SEMSIM partners can collectively procure equipment and services at lower costs than individual agencies. Additionally, the partners have agreed to allow snowplows to cross jurisdictional lines to assist one another with road treatment activities when necessary.

Implementation Issues: The SEMSIM project is funded with federal grants and matching contributions (i.e., 20 percent) by each partner. Phase one of the project was initiated in October 1998 and was scheduled for completion by December 1999. The partners developed specifications, issued a request for proposals, and contracted with a private vendor to furnish and install system components. This vendor was familiar with the region as they supplied the automated vehicle location system used to by the transit authority to monitor buses in the region.

The transit authority allowed the partners to use excess capacity in their radio communication system. Implementation problems with communication lines and devices caused delays in system acceptance and evaluation. A temporary dial-up telephone line was used for testing until technical difficulties were resolved. By the end of February 2000, the temporary system was in place and ten snowplows from each maintenance agency were equipped with system components.

A private firm was selected to evaluate each phase of the project. This firm conducted interviews and collected data to assess manager and driver needs, to document technical and institutional issues affecting operational decisions, and to determine whether or not project goals were met. An evaluation report of the first phase was released in June 2000. The partners then met to discuss plans for phases two and three. In June 2001 they contracted with the vendor to equip an additional 290 maintenance vehicles during 2002. System hardware and software will also be improved and the communication system will be web-based. The University of Michigan has enhanced central software by designing an application that will automate snowplow routing. As conditions change, the central software will calculate the most efficient routes and automatically notify drivers via in-vehicle devices.

Contact(s):

- Dennis Kolar, Road Commission for Oakland County, Director of Central Operations, 248-858-4718, dkolar@rcoc.org.
- Gary Piotrowicz, Road Commission for Oakland County, FAST-TRAC Project Manager, 248-858-7250, gpiotrowicz@rcoc.org.

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Keyword(s): winter storm, snow, ice, maintenance vehicle management system, winter maintenance, treatment strategy, advisory strategy, decision support, maintenance vehicle, air temperature, pavement temperature, pavement sensor, institutional issues, productivity

Minnesota DOT Access Control

Since 1996 several Minnesota Department of Transportation (DOT) maintenance districts have worked with the Minnesota State Patrol and county sheriffs to direct traffic off of freeways and to restrict freeway access at ramps when winter storms create unsafe travel conditions. After maintenance vehicles have cleared snow and ice, freeways are reopened to traffic.

System Components: Two types of gates are used to restrict freeway access. One maintenance district has installed gate arms that are positioned on the side of the road and swing into place when needed. These arms have amber lights. Other districts deployed upright gate arms, with red lights, that are lowered into position. Static fold-down warning signs are located in advance of gates to notify motorists of freeway closures.

System Operations: Traffic and maintenance managers consider several variables to identify threats to highway operations. Weather parameters include winter storm duration and severity (i.e., snowfall rate), and visibility. Pavement condition, time of day, day of the week, seasonal travel patterns, and the capacity of towns to accommodate diverted motorists are transportation system factors. Threat information is used to determine closure locations and times.

When a threat is identified traffic and emergency management personnel execute a systematic, coordinated plan to divert traffic off of freeways with mainline gates and prohibit freeway access using ramp gates. DOT personnel travel to gate locations to open warning signs and activate gate arm lights. As shown in the figure, gate arms are then positioned in travel lanes to alert drivers that the freeway is closed. During closure and reopening activities, uniformed law enforcement personnel staff gate locations with patrol vehicles to prevent motorists from interfering with clearing operations.

Minnesota DOT
Ramp Gates and Warning Signs

Transportation Outcome(s): During a severe snowstorm on November 11, 1998 a 50-mile (80.4-kilometer) section of Interstate 90 was closed, while 59 miles (94.9 kilometers) of US Highway 75 remained open. Plows made four passes on Interstate 90 and ten passes on Highway 75 to clear the pavement of snow and ice. The freeways were reopened when the pavement was 95 percent clear. Because Highway 75 was open to traffic, significant snow compaction occurred on this roadway. Delay on Interstate 90 was minimized, as it was cleared four hours before Highway 75. As shown in the following table, over 24 dollars per lane mile were expended on Highway 75, while it cost less than 20 dollars per lane mile to clear Interstate 90.

Minnesota DOT Access Control and Maintenance Costs

	US Highway 75 (Open to Traffic)	**Interstate 90** (Access Restricted)	**Percent Difference**
Number of Plow Passes	10	4	60%
Total Miles Plowed	590	200	66%
Labor Hours per lane mile	0.41	0.38	7%
Labor Costs per lane mile	$9.98	$9.08	9%
Material Costs per lane mile	$4.59	$4.50	2%
Equipment Costs per lane mile	$9.54	$6.14	36%
Total Costs per lane mile	**$24.11**	**$19.72**	**18%**

The DOT conducted a study of Interstate 90 closures in 1999. Analysis revealed that roughly 80 crashes per year were related to poor road conditions on the freeway. Study results also confirmed that access control operations enhanced mobility by reducing closure time and associated vehicle delay. Examination of this control strategy during a single storm event and over a six-month period indicated that productivity, mobility, and safety were improved.

Implementation Issues: The DOT contracted with a consulting firm to analyze the costs and benefits of deploying gate arms for access control. The consultant used historical operations and crash data to calculate benefits associated with reductions in travel time delay and crash frequency. After deciding to implement gate arms based upon the benefit/cost analysis, the DOT consulted agencies in North and South Dakota. An assessment of gates used in the Dakotas found that snowdrifts could block swinging gates necessitating shoveling before they could be positioned in the road. The upright gates also had disadvantages. In some cases, the pulley mechanism failed causing the gate arm to slam down unexpectedly. Individual maintenance districts selected the type of arm most appropriate for their operations. Ice and high winds occasionally interfered with the opening of warning signs.

The DOT plans to test remote operation of gates and Closed Circuit Television surveillance at one interchange. Remote monitoring and control via a secure web site will be tested during the 2002/2003 winter season.

Contact(s):
- Farideh Amiri, Minnesota DOT, ITS Project Manager, 651-296-8602, farideh.amiri@dot.state.mn.us.

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Keywords: winter storm, snow, ice, access control, freeway management, treatment strategy, winter maintenance, control strategy, traffic control, law enforcement, advisory strategy, motorist warning system, institutional issues, gates, maintenance vehicle, safety, mobility, productivity

Nevada DOT High Wind Warning System

The Nevada Department of Transportation (DOT) operates a high wind warning system on a seven-mile (11-kilometer) section of US Route 395. This highway segment, which is located in the Washoe Valley between Carson City and Reno, often experiences very high crosswinds (up to 70 mph or 113 kph) that pose risks to high-profile vehicles. The system provides drivers with advanced warning of high wind conditions and prohibits travel of designated vehicles during severe crosswinds.

System Components: An Environmental Sensor Station (ESS) is installed on the highway to collect and transmit environmental data to a central control computer in the Traffic Operations Center. The ESS measures wind speed and direction, precipitation type and rate, air temperature and humidity, as well as pavement temperature and condition (i.e., wet, snow or ice). During high wind conditions advisory or regulatory messages are displayed on Dynamic Message Signs (DMS) located at each end of the valley, as shown in the figure. Traffic managers may also broadcast pre-recorded messages via three Highway Advisory Radio transmitters in the area.

Nevada DOT
High Wind Warning on DMS

System Operations: The central control computer polls the ESS every ten minutes to compare average wind speeds and maximum wind gust speeds to preestablished threshold values. If the average speed exceeds 15 mph (or 24 kph) or the maximum wind gust is over 20 mph (or 32 kph) the computer prompts display of messages as shown in the table below. This is accomplished through an interface with a DMS computer, which runs proprietary software to control the roadside signs. Roadway access to high-profile vehicles is restricted when winds are extreme. Static signs identify critical vehicle profiles and direct specified vehicles to exit the highway and travel on an alternate route when "PROHIBITED" messages are displayed.

Nevada DOT High Wind Warning System Messages

Average Wind Speeds	Maximum Wind Gust Speeds	Displayed Messages
15 mph to 30 mph	20 mph to 40 mph	High-profile vehicles "NOT ADVISED"
Greater than 30 mph (48 kph)	Greater than 40 mph (or 64 kph)	High-profile vehicles "PROHIBITED"

Transportation Outcome: Dissemination of traveler information and access control have enhanced safety by significantly reducing high-profile vehicle crashes caused by instability in high winds.

Implementation Issues: In the early 1980s the first high wind warning system was constructed on US Route 395. It was comprised of an anemometer (or wind speed sensor), message signs, a relay, and a timer. Because this legacy system needed extensive repairs, it was replaced in the 1990s. A solar-powered ESS was installed in place of the anemometer and relay components, and each message sign was substituted with a DMS.

While developing equipment requirements and operational procedures for the system upgrade, the DOT worked with the University of Nevada to determine warning threshold values. The University analyzed the stability of various vehicle profiles, configurations, and loadings to calculate critical wind speeds (i.e., sufficient speeds to blow vehicles over).

In 1996 the DOT's statewide telephone communication system and Very High Frequency radio network were replaced with a digital, wireless radio communication system. A Wide Area Network (WAN) facilitated the integration of voice, video, and data using open system protocols. The WAN also allowed dissemination of traveler information via the Internet (*www.nvroads.com)* and through telephone systems (*1-877-NVROADS*) with interactive voice response technologies. The computing and communication networks were designed with the flexibility to easily incorporate new technologies or components.

Contact(s):

- Richard Nelson; District Engineer, Nevada DOT District 2, 775-834-8344, rnelson@dot.state.nv.us.
- Denise Inda, Traffic Engineer (ITS), Nevada DOT District 2, 775-834-8320, dinda@dot.state.nv.us.

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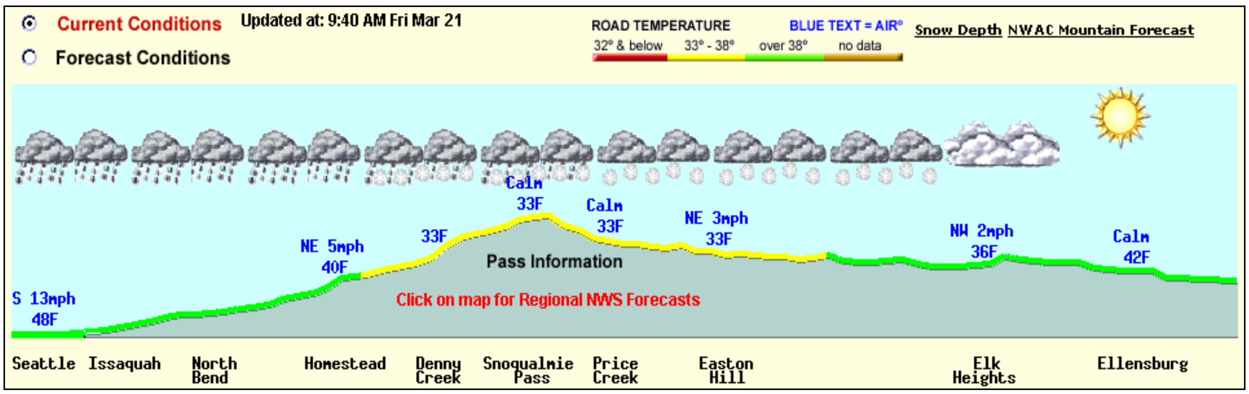
Keywords: wind, high-profile vehicles, high wind warning system, freeway management, traffic management, control strategy, access control, advisory strategy, traveler information, internet/web site, environmental sensor station (ESS), dynamic message signs (DMS), highway advisory radio (HAR), safety

Washington State DOT Road Weather Information for Travelers

The Washington State Department of Transportation (DOT) has collaborated with the University of Washington to provide travelers with comprehensive, integrated road weather information. The DOT maintains one of the most advanced traveler information web sites, which allows users to access current and predicted road weather conditions on an interactive, statewide map.

System Components: The DOT owns 50 Environmental Sensor Stations (ESS) that collect air temperature, atmospheric pressure, humidity, wind speed, wind direction, visibility distance, precipitation, pavement temperature and subsurface temperature. Some stations are equipped with Closed Circuit Television (CCTV) for visual monitoring of pavement and traffic flow conditions. The DOT is also a member of the Northwest Weather Consortium, which collects and disseminates real time data from an extensive environmental monitoring network. This network gathers and disseminates data from over 450 ESS owned by nine local, state and federal agencies. A statewide communication network transmits this ESS data to the Seattle Traffic Management Center (TMC) and to a computer at the University's Department of Atmospheric Sciences for data fusion and advanced modeling.



Washington State DOT Route-Specific Road Weather Information Display

System Operations: A sophisticated computer model developed by the university ingests ESS data to determine prevailing and predicted pavement temperatures and generate high-resolution, numerical weather forecasts for the entire state. Observed environmental data is integrated with other information including National Weather Service (NWS) forecasts, satellite and radar images, video from 350 CCTV cameras, traffic flow data from inductive loop detectors, incident and construction data, ten mountain pass reports, and audio broadcasts from four Highway Advisory Radio (HAR) transmitters. As shown in the figures, route-specific traveler information is disseminated through the DOT's Traffic and Weather web site (*www.wsdot.wa.gov/traffic*) and via an interactive voice response telephone service (*800-695-ROAD*).

Washington State DOT Video of Selected Route with Vehicle Restrictions

To make travel decisions, the public may access the web site to view state, regional and local maps with environmental observations, weather and pavement condition forecasts, video from freeway CCTV cameras, information on road maintenance operations, and travel restrictions on mountain passes (e.g., reduced speed limits, prohibited vehicle types).

Transportation Outcome: Road weather data available through the web site and telephone service allows users to avoid hazardous conditions, modify driving behavior, and reduce crash risk. A user survey found that travelers feel safer when they have access to real-time road weather information. The survey also revealed that users frequently access the web site to prepare for prevailing conditions along a selected route (i.e., 90 percent of respondents), for general weather conditions (i.e., 86 percent), to check weather for a specific recreational activity (i.e., 66 percent), and to determine travel routes or travel time.

Usage logs from the web site indicate that travelers access condition data more frequently during adverse weather events. On average, there were over 3,700 user sessions per day in February 2001. During a snowstorm on Friday, February 16th (before a three-day weekend) site usage increased to nearly 13,000 user sessions. The interactive telephone service typically receives one million calls each winter (i.e., an average of 8,000 calls per day) with call volumes increasing during inclement conditions or major incidents.

Maintenance managers also benefit from access to detailed road weather data. This data serves as support for operational decisions, such as resource allocation and treatment planning. More effective and efficient resource decisions reduce labor, equipment and material costs. The ability to employ proactive road treatment strategies, such as anti-icing, also improves roadway mobility.

Implementation Issues: The web site project was funded by a grant from U.S. Department of Transportation and a 20 percent match from Washington State DOT. To collect environmental data for the site, the DOT wanted to procure ESS from different vendors and display field data on a single user interface. Project managers developed functional specifications and issued a request for proposals to furnish ESS capable of communicating with an existing server using National Transportation Communications for ITS Protocol (NTCIP) standards. After resolving technical issues related to object definitions, one vendor successfully demonstrated that their sensor stations could communication with another vendor's server.

This simplified management of environmental data and avoided the need for additional hardware, software and communications infrastructure. By using the open communication standard the DOT encouraged competition among vendors that reduced ESS procurement costs by nearly 50 percent. The NTCIP will also facilitate future expansion of the environmental monitoring system.

The Washington State DOT has initiated a project to deliver traveler information via 511, the national traveler information telephone number. The agency is developing a program with natural language speech recognition to read web site data and disseminate tailored information. The DOT is in negotiation with local cellular telephone companies to offer 511 free of charge. The toll-free telephone number will be phased out as the 511 implementation project proceeds.

Contact(s):

- Larry Senn, Washington State DOT, Olympia Traffic Operations Office, 206-543-6741, larsenn@u.washington.edu.
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Keyword(s): adverse weather, road weather information for travelers, traveler information, advisory strategy, weather information, pavement temperature, environmental sensor station (ESS), closed circuit television (CCTV), Internet/web site, decision support, institutional issues, road weather information system (RWIS), safety, productivity