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.

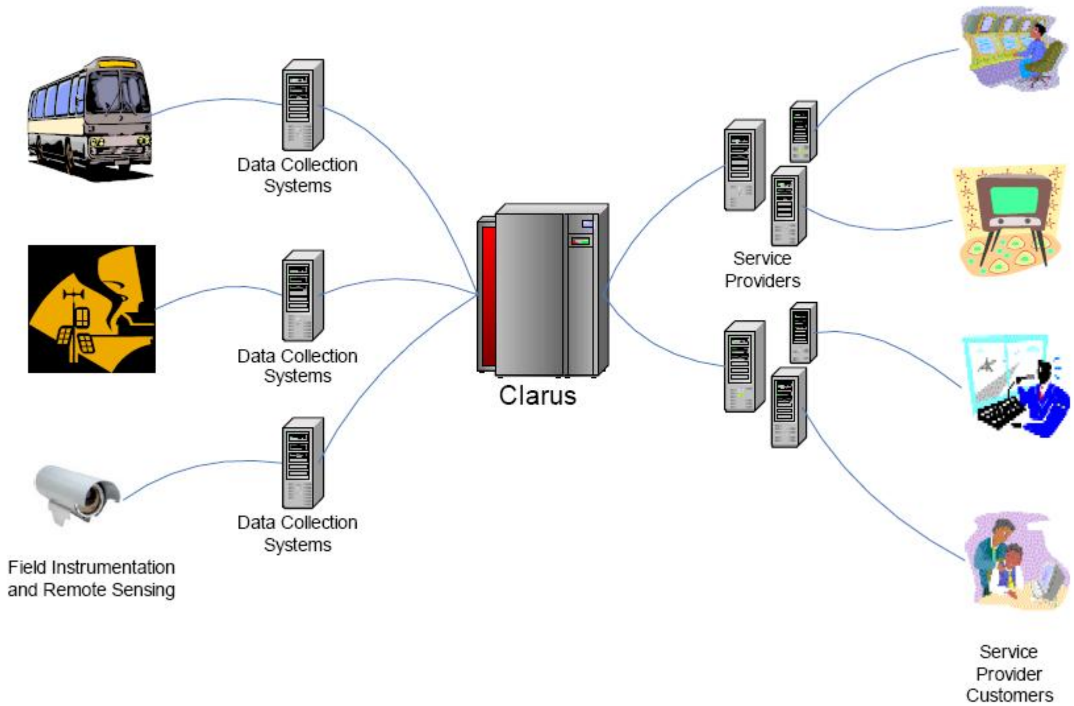
In 2007, 21 state transportation agencies were using or developing MDSS tools. Fourteen states have joined the MDSS Pooled Fund Study *(discussed in more detail in the Relevant Coalition White Paper included in this packet)* led by the South Dakota DOT to develop an enhanced version based on the federal 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

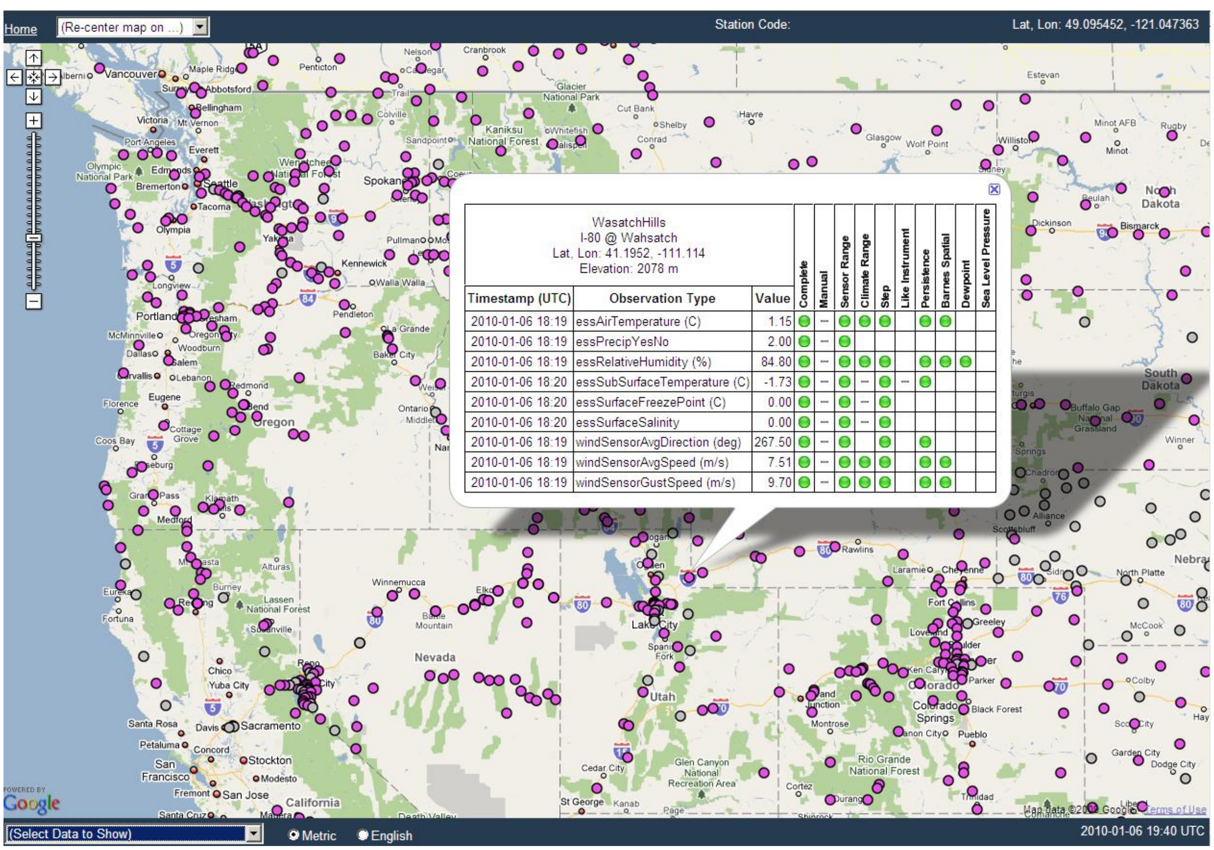


Figure – Clarus System Map View

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.

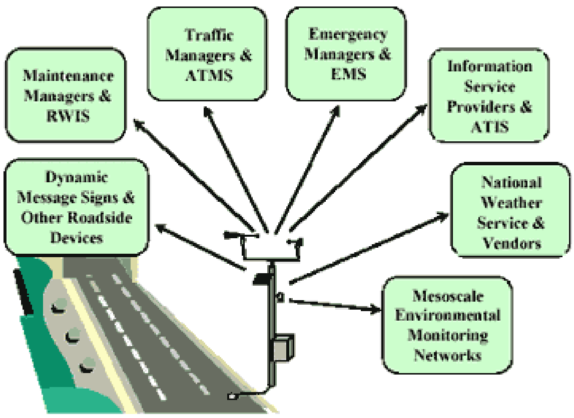


Figure – ESS Operational Applications

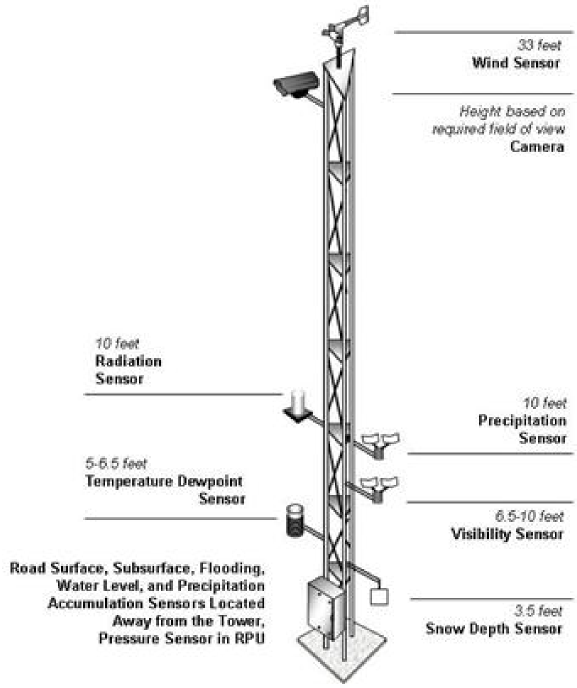


Figure – Environmental Sensor Station

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.

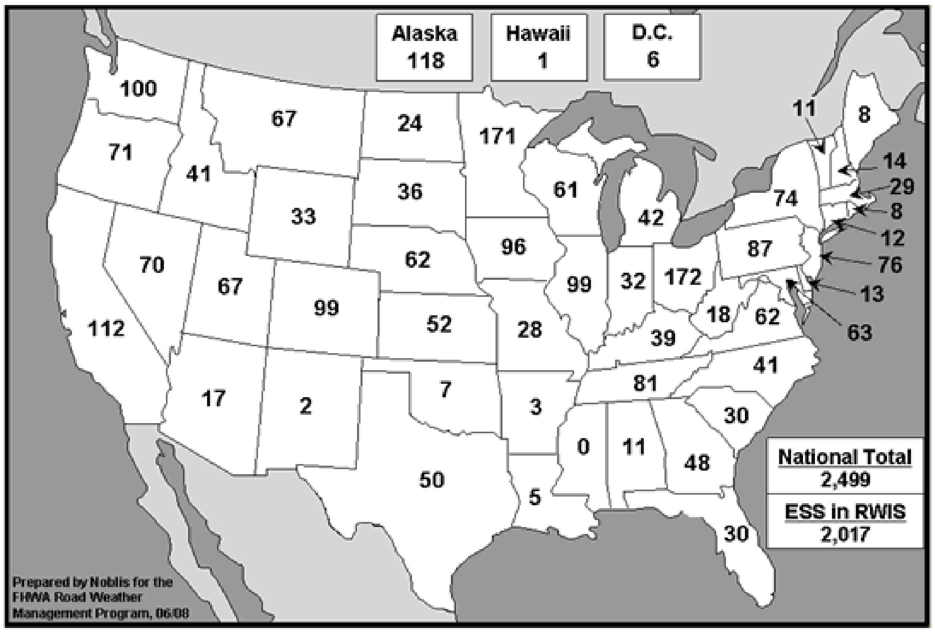


Figure – National Environmental Sensor Station Map

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.