Results of the *Clarus* Regional Demonstrations

Evaluation of Four Decision Support Tools

The *Clarus* Initiative is a research effort of the U.S. Department of Transportation Intelligent Transportation Systems (ITS) Joint Program Office and the Federal Highway Administration's (FHWA) Road Weather Management Program (RWMP) to develop and demonstrate an integrated weather observation data management system that can reduce the impact of adverse weather conditions on surface transportation.

Under this initiative, a data management system was developed to accept, quality check, and disseminate the weather and road condition data collected by Environmental Sensor Stations (ESS) installed along the nation's roads. This system is called *Clarus*. In a complementary effort to explore the value of the data disseminated from the *Clarus* system, four innovative application tools were developed, deployed, and independently evaluated between 2009 and 2011. The evaluation focused on the way in which selected state departments of transportation (DOT) used the tools in an operational environment. The four tools included enhanced road weather content for travel advisories, the seasonal load restriction tool, the non-winter maintenance decision support tool, and the multi-state control strategy tool. The states that demonstrated the tools along with a description appear in Table 1.

Table 1: *Clarus* Application Tools

Enhanced Road Weather Content for Travel Advisories	
Description: This tool offers State DOTs forecasts of pavement conditions impacted by weather up to 12 hours into the future; a capability not previously available. In the demonstrations, the tool integrated atmospheric conditions and road surface conditions for interstates in six northern tier states and incorporated it into traveler information systems. The multi-state aspect of the integrated interface for the road weather information was a capability important to all the users and travelers for trip planning and execution.	**States** Idaho; Montana; North Dakota; South Dakota **Audience/Users** Traffic managers and operators; travelers
Seasonal Load Restriction Tool	
Description: This decision support tool used past and current weather observations, long-lead time weather forecasts, and characteristics of the subpavement thermal and moisture profiles to create soil stability forecasts for engineers who must impose and subsequently lift restrictions on selected roads that are prone to road damage from heavy trucks during freezing/thawing conditions.	**States** Montana; North Dakota **Audience/Users** Traffic engineers and operators
Non-Winter Maintenance Decision Support Tool	
Description: This decision support tool expands upon the Maintenance Decision Support System, offering State DOT road maintenance personnel the ability to improve how they schedule their maintenance activities based on real-time and predictive weather conditions, offering them the ability to save on time, labor and material costs, and to operate more efficiently and safely.	**States** Iowa; Illinois **Audience/Users** State road maintenance engineers/supervisors
Multi-State Control Strategy Tool	
Description: This tool offers State DOTs a capability to communicate traffic and weather information within multi-jurisdiction networks of key agencies and stakeholders, such as traffic operators, emergency responders, state law enforcement agencies, and weather experts. The tool provides automated road-weather alerts to all participants in the network simultaneously, along with action responses as conditions evolve.	**States** Iowa; Illinois **Audience/Users** DOT/TMC operators; emergency responders; state patrol; weather experts

Further information about each tool can be found in the following publications: Seasonal Load Restriction Tool, FHWA-JPO-11-156; Multistate Control Strategy Tool, FHWA-JPO-11-157; Maintenance and Operations Decision Support Tool, FHWA-JPO-11-158; and Enhanced Road Weather Content for Travel Advisories, FHWA-JPO-11-159.

Methodology

A formal, independent evaluation was conducted for each of the four tools to measure the level of user satisfaction. Quantitative and qualitative data measured benefits, as well as the potential long-term value that further development and deployment might offer. Table 2 summarizes the data collected for each of the four tools and the analysis conducted on those data.

Table 2. Methodology

Tool	Data Collected	Analytic Methods
Enhanced Road Weather Content for Travel Advisories	• Commercial operator and public traveler focus group opinions and usage data; • Survey opinions from users of the experimental web site; and • Interviews with State DOT users.	• Categorize and assess focus group comments on the tool; • Qualitative and quantitative analysis of web-based survey; and • Categorize and interpret user perceptions and comments.
Seasonal Load Restriction Tool	• Modeled subsurface temperature and moisture conditions at selected sites; • Visual road thaw reports; • Environmental Sensor Station subsurface data records; • Phone interviews with DOT maintenance personnel; and • Motor carrier web survey data.	• Use of the tool in making restriction placement and removal decisions; • Categorize comments by maintenance chiefs on utility of the tool; and • Assess impact of restrictions on motor carriers and potential of tool to mitigate those impacts.
Non-Winter Maintenance Decision Support Tool	• Daily crew work assignment reports; • Maintenance work activity plans; and • Agency satisfaction interviews.	• Track experiences of experimental and control work crews and efficacy of alerts from the tool; • Assess effects of the tool on work scheduling efficiencies and schedule adjustments; and • Assess agency satisfaction and expectations for the tool.
Multi-State Control Strategy Tool	• Usage of the tool over time; • Use of tool in a tabletop exercise, followed by focus group interviews; and • Perceived usefulness by agency.	• Aggregate and assess comments from tabletop exercise; • Content analysis of interviews; and • Analyze usage of tool based on alerts generated.

Evaluation Results

Enhanced Road Weather Content for Travel Advisories

The evaluation results for this tool were positive with users expressing their desire for the tool to be further refined and integrated into their state web sites (78 percent agreed). Additional results included the following:

- Users value access to uniformly presented road-weather information across several states. This is particularly true for commercial operators and those planning longer trips.
- Seventy-four percent of the web survey respondents said they adjust their travel plans or trip based on weather information.
- Eighty-seven percent of the survey respondents said providing current pavement condition information is useful.
- A majority of the survey respondents said they found the information useful for deciding whether to postpone a trip (79 percent), taking an alternate route (77 percent), or deciding when to start their trip (75 percent).
- State DOT officials saw a clear need for such a tool (7.7 on scale of 0 to 10) but were concerned about the costs and complexity of adapting the information to their current information displays. They scored the "fit" of this tool with others they currently use (5.8 on the scale of 0 to 10).

Seasonal Load Restriction Tool

Prior to the Seasonal Load Restriction Tool, DOT engineers based their restriction decisions primarily on observed pavement conditions and atmospheric weather forecasts. With the tool, engineers can access data on forecasts of subsurface temperatures and moisture content up to two weeks into the future; data not previously accessible. Following are some of the advantages of the tool:

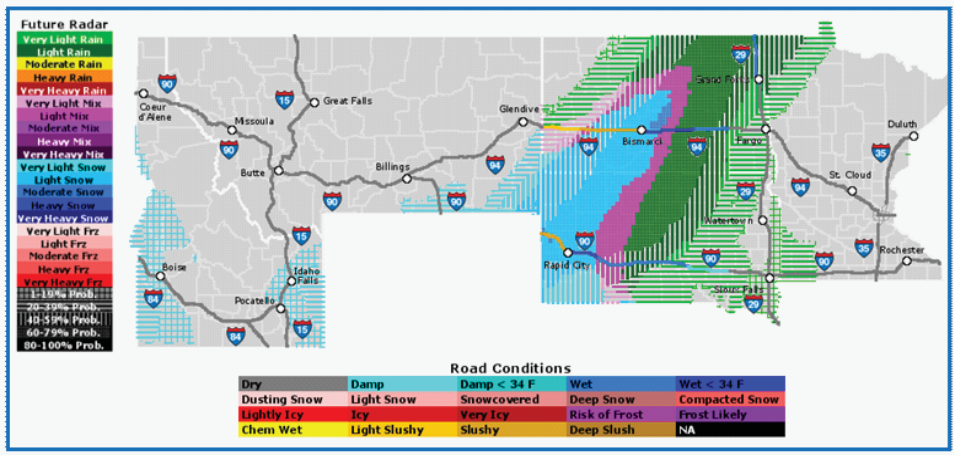
- Delayed restriction placement by 14 days in North Dakota following an early but short warming period which shortened the total restriction period and reduced the impact on commercial operations.
- Placed restrictions seven days sooner in a Montana district which protected the pavement surface from truck load damage.

This photo, courtesy of the Texas Transportation Institute, shows pavement damage caused by heavy vehicles during spring thaw.

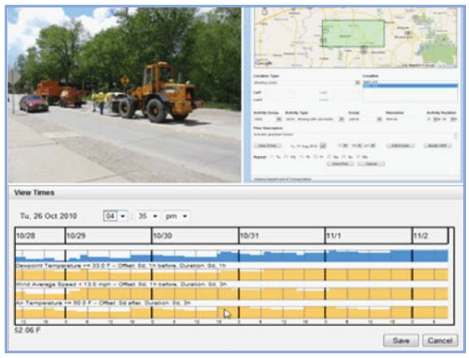
State DOT users also reported a high level of trust in the information, and their perception of the "reliability and/or accuracy of the information" was equally high. The users expected the tool would shorten restriction periods, support more advance notification of restriction placement and removal, and offer better protection of road integrity. The surveyed commercial operators valued the consistency and fairness of restriction decisions, and reductions in the length of the restriction period, a potential benefit, was important to 86 percent of the motor carrier respondents. While users and operators valued the tool's benefits, they requested further verification and validation of the sub-surface condition forecasts as a basis for establishing greater trust and use of the tool.

Non-Winter Maintenance Decision Support Tool

Many non-winter road maintenance activities are potentially impacted by weather, and the scheduling of these activities is guided by a set of operating rules for performing various maintenance tasks. For example, pavement repairs may require dry weather above a critical temperature threshold, and weed spraying may require no wind or rain. The tool integrated these operational rules with *Clarus*-enhanced weather information to improve the scheduling of the maintenance tasks. The tool gave maintenance chiefs the ability to more accurately schedule their activities several days in advance. The evaluation examined the efficiency and productivity benefits of the tool, particularly regarding the assignment of labor, equipment, and materials. It also assessed the accuracy of identifying the "windows of opportunity" and completing tasks as scheduled.



This figure, courtesy of Meridian's experimental web site, shows precipitation and road condition forecast for interstates across Idaho, Montana, North Dakota, South Dakota, and Minnesota on April 2, 2010.

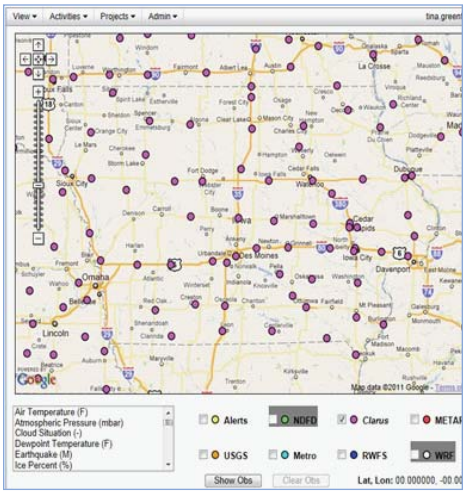


This figure and photo show a road patching operation and a road weather condition forecast from the Non-Winter Maintenance Decision Support Tool. Photo at top left courtesy of the Iowa DOT; figures at top right and bottom courtesy of Mixon Hill, Inc., Clarus Regional Demonstration web site screen shots.

The evaluation results were mixed with various tool modifications required during the evaluation period. In addition, one of the two user states found the tool was effective adjusting daily maintenance schedules to account for weather forecasts.

- One state experienced 15 days out of 64 when activities were impacted by weather. The tool was only helpful in three of the weather days due to technical problems, including communication and software issues, which prevented the state from using the tool. Some of these technical issues were resolved during the evaluation period.
- Out of 37 days of tool use in the other state, 11 schedule changes were made based on the tool, resulting in greater efficiencies.
- The tool was helpful in scheduling routine maintenance several days in advance, but given the fact the agencies were flexible and adept at last minute maintenance scheduling this was not seen as a critical need.
- Users recommended the tool focus on certain weather-critical maintenance activities such as concrete and asphalt work because there is less time flexibility, or for those activities that required acquisition of resources or contracted services outside their area. By focusing the tool on specific activities, the benefits can be more apparent to users.

Multi-State Control Strategy Tool (MSCST)



This screen shot from the Clarus Multi-State Control trategy Tool web site, courtesy of Mixon Hill, Inc., shows locations of weather monitoring stations available through MSCST in Iowa.

The State DOTs involved in the demonstration and evaluation of this tool assessed how stakeholders used the tool, how it affected their responses and decisions, and how they rated the value of the information. The DOTs used the tool in an off-line setting as part of a table-top exercise, and for sharing weather alerts during actual events. While agencies agreed the overall concept of the MSCST was valid, significant modifications to the tool are needed before it will be ready for widespread deployment and acceptance. Users noted the potential value of the tool to link a variety of agencies and actors in a real-time information-sharing network that integrates road conditions, weather forecasts, and incident data, yielding automated alerts to prompt coordinated decision making and action. Other observations include the following:

- During emergency events, the tool should be deployed in a dispatch or control center where it can be actively monitored since on-scene responders are too busy to enter or access tool information.
- For cross-jurisdictional control coordination, agencies want to invite participants via the tool into an evolving situation on-the-fly, rather than only being able to set up the participant list in advance.
- Field users would like the tool to indicate the likely impacts of weather on the events they are managing, along with start-stop weather event forecasts and more decision guidance.
- Agencies desire greater ease in setting the weather alerts in the tool, along with a clear link between weather and its impacts on the roadways.

Conclusions

These four *Clarus* demonstrations were well received by the participant State DOT users. While they assessed the concepts behind each of these demonstrations favorably, they felt that further refinements will be needed to boost trust and confidence in the information provided and to adapt them in the most useful ways to their current operational systems and procedures. Some cross-cutting conclusions and lessons include the following:

- The applications showed promise in translating *Clarus* data to user-oriented applications and decision support tools. Concepts were rated highly by the State DOTs, especially those that added new functionality to the State DOT toolbox.
- Application development should carefully consider the user interface, focusing on the delivery of information most pertinent to the user. As *Clarus*-enabled applications provide more information and capabilities to the user, it is important to consider not only what information is needed but also how this information can best be presented to the user during the design and use phases.
- The appeal of these demonstrated tools is mainly due to the ability to translate existing sensor station data into new, actionable intelligence for the user. Tools that provide new capabilities (such as the seasonal load restriction tool) may be more attractive for adoption than tools that only supplement existing approaches.

The photos in this publication other than those attributed are courtesy of the RWMP.

U.S. Department of Transportation
Road Weather Management
1200 New Jersey Avenue, SE, E86-205
Washington, DC 20590

Paul Pisano
202-366-1301
E-mail: paul.pisano@dot.gov
http://ops.fhwa.dot.gov/Weather/index.asp

Federal Highway Administration
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"Anytime, Anywhere Road Weather Information"

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