Clarus Multi-State Regional Demonstrations

Evaluation of Use Case #4: Multi-State Control Strategy Tool

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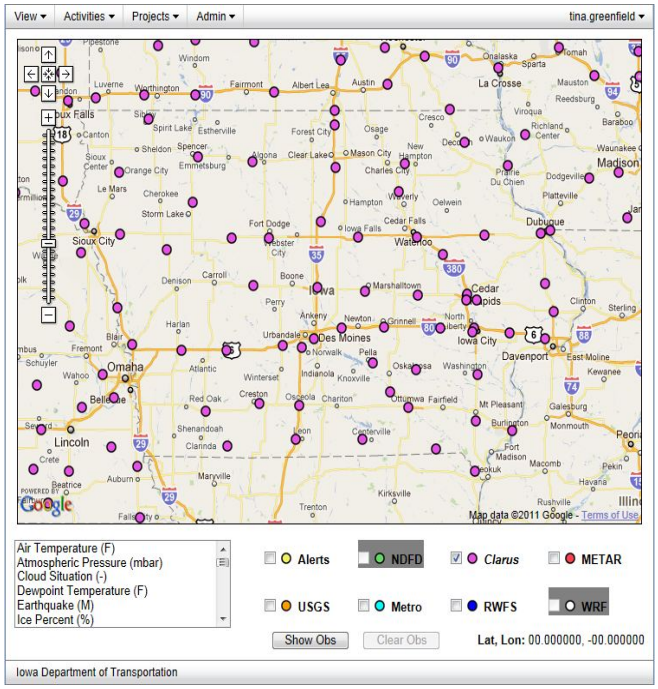

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16. Abstract

This report provides the results of an independent evaluation of the *Clarus* Use Case #4 Multi-State Control Strategy Tool (MSCST). This tool, developed for the Road Weather Management Program of the Federal Highway Administration by a private contractor under a separate contract, allows state DOTs to proactively manage traffic and coordinate their responses to developing significant weather events. The tool allows users to monitor weather conditions, receive alerts when weather conditions deteriorate beyond established thresholds, and communicate response decisions to other state and local agencies that may be impacted either by the weather conditions or the traffic management strategy. The tool was demonstrated in two states (Iowa and Illinois) as part of the *Clarus* Multi-State Regional Demonstration Program. The evaluation consisted of deploying the tool for three months in each of these agencies and collecting statistics on how agencies used the tool to improve and coordinate responses during significant weather events, specifically potential frost conditions, precipitation on cold pavement events, slick road events, and blowing snow events. The study found that while agencies felt the concept of the MSCST was valid, the current tool needs significant expansion of its current utilities and sophistication before widespread acceptance and deployment can be expected.

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Preface/ Acknowledgements

The Multi-State Control Strategy Tool (MSCST) is one of several tools developed under the *Clarus* Multi-State Regional Demonstration Program. This program is administered by the Road Weather Management Program of the Federal Highway Administration, U.S. Department of Transportation. The MSCST was developed by Mixon Hill, Inc.

The evaluation team would like to thank Tina Greenfield with the Iowa Department of Transportation and Dean Kernan and Veronica Sarver of Illinois Department of Transportation for agreeing to incorporate the tool into their daily operations and for participating in the evaluation of the tool. The evaluation team would also like to thank Brenda Boyce with Mixon Hill, Inc. for her assistance in developing and coding the conferences used by the agencies in this evaluation, for providing training and support on the use of the tool, and for her assistance with demonstrating and operating the tool during the tabletop exercise.

Furthermore, the evaluation team would also like to thank the emergency responders from the Quad City area of Iowa and Illinois for participating and providing their honest feedback in the tabletop exercise conducted as part of this evaluation.

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List of Acronyms

DOT ..... Department of Transportation
ESS .....Environmental Sensor Station
FHWA .....Federal Highway Administration
IDOT ..... Illinois Department of Transportation
Iowa DOT .....Iowa Department of Transportation
MSCST .....Multi-State Control Strategy Tool
NCDC .....National Climatic Data Center
NWS .....National Weather Service
RWIS .....Road Weather Information System
RWMP .....Road Weather Management Program
USDOT ..... United States Department of Transportation

Executive Summary

The *Clarus* Multi-State Regional Demonstration Program leverages the quality-checked data available through the national network of Environmental Sensor Stations called the *Clarus* System to test and provide road weather management applications for state and local agencies. This document describes the approach and findings from an independent evaluation of the use and benefits of Use Case #4:Multi-State Control Strategy Tool (MSCST), a tool developed and tested under the *Clarus* Multi-State Regional Demonstration Program. The tool allows decision-makers in one state to have knowledge of and access to the latest advisory and control information and deployment decisions made by other states/agencies in a timely manner. The independent evaluation of this use case tool examined how the Iowa Transportation Department (Iowa DOT) and the Illinois Department of Transportation (IDOT) used the tool during a three-month period to improve their coordination and communication during specific significant weather events. These DOTs established weather alerts to provide warning of the following different weather events:

- Bridge frost development.
- Blowing snow.
- Precipitation on cold pavements.
- Slick road condition.
- Limited visibility.
- High winds.
- Precipitation in excess of a particular rate.

Multi-State Control Strategy Tool (MSCST)

The MSCST was developed by Mixon Hill, Inc. for the Federal Highway Administration's Road Weather Management Program. The tool improves coordination and information dissemination between agencies at all levels during weather events. Through the use of "conferences," it was envisioned to assist agencies in disseminating information about the advisory and control decisions made during weather events to other partnering agencies in a timely manner. The tool was also envisioned to facilitate the participation of stakeholders who are not presently "in the loop" regarding communications on events that involve weather, and to fill gaps in how agencies communicate and share information about traffic management responses and actions taken in response to weather events with other agencies as well as internally. The tool was designed so that agencies could share information about automated responses and actions in an almost instantaneous manner. The tool provided users with access to real-time weather observational data from *Clarus* and other weather information providers.

Evaluation Approach

The approach to evaluating this use case began with the development of an Evaluation Strategy that identified the expected benefits of the tool use and developed a set of testable hypotheses. A more detailed Evaluation

Plan was prepared to guide the data collection and analysis. This was refined as more information about the demonstration and opportunities to collect data became available. Iowa DOT and IDOT agreed to deploy and test the tool during a three-month evaluation period. The agencies' operations supervisors and dispatch personnel were asked to use the tool to assist them in making and coordinating response decisions to the above listed weather events. For IDOT, this included the area operations engineering and the a maintenance dispatch supervisor. For Iowa DOT, the road weather information system coordinator evaluated the tool. Field and incident responders from various agencies utilized the tool as part of a tabletop exercise.

An evaluation was conducted to assess the usefulness and effectiveness of the tool in assisting agencies to proactively respond to and manage traffic operations in a coordinated fashion during these weather events. The evaluation focused primarily on three questions:

- How did having access to the tool change responses of agencies during each actual weather event?
- Did agencies use forecasted weather information to make advisory and control decisions?
- Did agencies feel they were more informed and had better access to information about surrounding conditions and actions of other agencies when they made their advisory and control decisions?

The evaluation used a combination of studies to answer these evaluation questions that were refined and framed into testable hypotheses. First, usage statistics were collected to determine the frequency with which alerts were received about the above listed weather conditions and whether and when agencies responded proactively to these alerts. Second, the evaluation team conducted a tabletop exercise to assess how the tool could be potentially used to assist in coordinating responses between transportation operators and emergency responders during an incident under changing weather conditions. Finally, agency interviews were conducted to assess user perceptions of the utility and maturity of the MSCST in assisting agencies in developing and coordinating advisory and control traffic management responses during weather events.

Evaluation Findings

Table ES-1 provides a summary of the hypotheses considered as part of this evaluation study. The findings from the evaluation study generally show that inter-agency cooperation and communications were *not* improved through the use of the tool. While agencies used the tool to receive alerts about changing weather conditions, there were no recorded or logged responses indicating that the tool changed the way that agencies responded to these events. Furthermore, the evaluation team could not find any evidence that the agencies used the tool to share information about how they responded to weather conditions. During the evaluation period, the tool was used by the agencies primarily as a tool for issuing alerts about potential deteriorating (or improving) weather conditions. Several possible explanations, supported by comments obtained during the tabletop exercise and the agency interviews, are offered as to why the MSCST was not used by agencies to improve coordination and cooperation:

- In the deployment area, both the Iowa DOT and IDOT already have well-established processes, protocols, and procedures for sharing their responses during weather events.
- The time period for the evaluation was too short. Agencies needed more time to develop a level of trust with the tool. Traffic management agencies are historically cautious (and rightly so) about adopting new tools and technologies. Agencies need time to determine the full extent of the tool's capabilities, features, and limitations before they can comfortably fully adopt it for wide-scale deployment or consider substituting a new tool for existing well-understood tools.

- During the initial deployment phase, the users identified several significant limitations and issues with the current implementation of this experimental tool. These limitations included the following:
  - An easier interface and methodology for creating new conferences. The tool needs to be revised to allow agencies to develop conferences on an as-needed basis (as opposed to pre-establishing conferences).
  - The process of establishing thresholds and weather evaluation strategies needs to be greatly expanded and simplified to support more sophisticated evaluations of weather conditions and situations.
  - The manner in which the weather information is presented needs to be improved to support graphics and animation.

Table ES-1. Summary of Results of the Use Case #4: Multi-State Control Strategy Tool Evaluation Study

Hypotheses	Evidence	Level of Support
Having access to accurate and timely weather information through the MSCST helped agencies proactively respond to changing roadway and travel conditions resulting from changing weather conditions.	• The tabletop exercise revealed that field personnel are not likely to take the time to use the tool to enter and extract weather information. Field personnel need to know when and for how long weather will be impacting response. • Agency interviews revealed that significant modifications are needed with respect to the manner in which weather information is presented. Responders preferred processed weather information over general observation data.	Minimal Support
As a result of using the MSCST, agency responses to weather-related events are better coordinated.	• Use statistics and agency interviews suggest that the tool did not improve coordination between agencies. In the test areas, the response agencies already have clearly identified and strong lines of communication. During weather events, agencies preferred to use these trusted lines of communication over the MSCST. The telephone is the primary tool of choice for coordinating responses.	No Support
Because of using the MSCST, agency responses to weather-related events are more timely and appropriate	• Usage statistics and agency interviews suggest that the tool was not used by agencies to improve the timeliness of responses to weather events. The tested configuration of the tool supported only a limited number of weather event configurations used to trigger alerts (4 in Iowa, and 6 in Illinois). Significant revisions to the event trigger decision-making are needed to improve the level of sophistication of the triggers.	No Support
State DOTs view the MSCST as useful and beneficial for improving coordination between agencies during weather events.	• Results for agency interviews revealed that significant modifications are needed to the MSCST to improve its usefulness in coordinating responses between agencies. These improvements include providing capabilities to search for responses, providing map overlay showing the latest response/action taken by operators, and setting milestones so that the current status of an event can easily be determined. • With some revisions, the tool could be used as a resource tracking tool to let agencies know the availability of resources, particularly that status of personnel (who as on-duty and who was off-duty), contact information, etc. during weather events.	Minimal Support

- Weather information needs to be processed and interpreted for transportation agencies. It has to be more than just observational data.
- Additional features (such as a search feature) need to be incorporated to increase user friendliness.
- The tool needs to incorporate weather forecast information so that agencies can not only tell what conditions are currently like, but also determine the time that driving conditions are likely to start to deteriorate and how long that is expected to last because of weather conditions.

Conclusions

Based on the findings of the usage statistics, agency interviews and tabletop exercise, the overall conclusion of this evaluation is that while agencies generally agreed that 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. These suggested modifications include the following:

- Improving the tool to make it easier to use and navigate between screens and multiple conferences. This would include making it easier to define and establish a conference as well as defining thresholds for issuing alerts.
- Developing a single interface that shows weather conditions, alerts, and agency responses all in a single window, instead of spread over multiple windows.
- Revising the tool to allow support of graphical representation of responses as well as supporting animations of forecasted weather conditions to allow agencies to better visualize impending weather events in the future.
- Providing processed weather information (such as maps and forecasts for impacts) instead of raw observations directly from weather monitoring stations.
- Allowing users to define the type and timeframe for obtaining weather forecast information.

Furthermore, the tool, as currently envisioned, is best suited for dispatch and control center personnel, and not field personnel. Emergency responders indicated that during incident events, they do not have the time to check weather conditions once they are managing an incident condition. Rather, field emergency responders would prefer to be alerted by dispatchers and control center operators of the time when significant weather changes are likely to occur.

1 Introduction and Background

The *Clarus* Multi-State Regional Demonstration Program leverages the quality-checked data available through the national network of Environmental Sensor Stations (ESS) called the *Clarus System* to test and provide road weather management applications for state and local agencies. Five use cases were developed as part of the demonstration:

- Use Case #1 – Enhanced Road Weather Forecasting
- Use Case #2 – Seasonal Weight Restriction Decision Support
- Use Case #3 – Non-Winter Maintenance Decision Support System
- Use Case #4 – Multi-State Control Strategy Tool
- Use Case #5 – Enhanced Road Weather Traveler Advisories

The use case development was led by two deployment teams. Each team was comprised of a private-sector system developer and several state agencies where the use case was tested. Two independent evaluations also were conducted. The first evaluation assessed the improvements in road weather forecasting in use case #1 from a meteorological perspective. The second set of four evaluations assessed the value of the remaining four use cases to selected state DOTs during 2010 and early 2011. The evaluation of the four use cases (#2 to #5) sought to understand the systems' impacts and benefits experienced by the state agencies and end users, including transportation managers, related agencies, and travelers.

This document describes the approach to independently evaluate the value and applicability of *Use Case #4 – Multi-State Control Strategy Tool*, a tool being developed as part of the *Clarus* Multi-State Regional Demonstration Program.

2 Description of the Use Case

When severe weather occurs, the impacts are often not limited to a single region or an individual state. In managing traffic operations and travel in response to these events, decisions made in one jurisdiction can have a significant impact on the sets of decisions and management options available to bordering jurisdictions. For example, one agency's decisions on how to manage traffic during a significant weather event may place new or unanticipated demands on the transportation system in another jurisdiction, which may also be experiencing similar deteriorating weather and roadway surface conditions. Similarly, to influence travelers' decisions, it may be desirable to warn them far in advance of where and when travel conditions are currently or are expected to become hazardous or congested. This may create the need to provide travelers with information across state lines, including regions not directly affected by the specific weather event. Under such conditions, effective response strategies for traffic control and information dissemination require a degree of coordination between neighboring agencies and jurisdictions. However, in the midst of responding to rapidly unfolding weather events, it is often difficult for agencies to coordinate their responses because of a lack of tools that allow agencies to simultaneously share information between multiple jurisdictions.

One objective of the *Clarus* MSCST is to improve coordination and information dissemination between agencies at all levels during weather events. Through the use of "conferences," the MSCST was envisioned to facilitate the participation of state and local transportation and emergency response officials who may not presently be "in the loop" regarding communications on weather-related information in an event. Conferences provide agencies a mechanism to establish communications in a way that includes all the affected parties. The MSCST was also envisioned as a solution to filling gaps in states' current communication systems and networks ensuring lines of communication are automated and almost instantaneous. Everyone gets the message at the same time, no one is inadvertently left out, and in addition, everyone sees all responses/action decisions related to a shared piece of information. Currently, both Iowa DOT and IDOT communicate responses via voice communications (radio and telephone) and/or through text messaging or email.

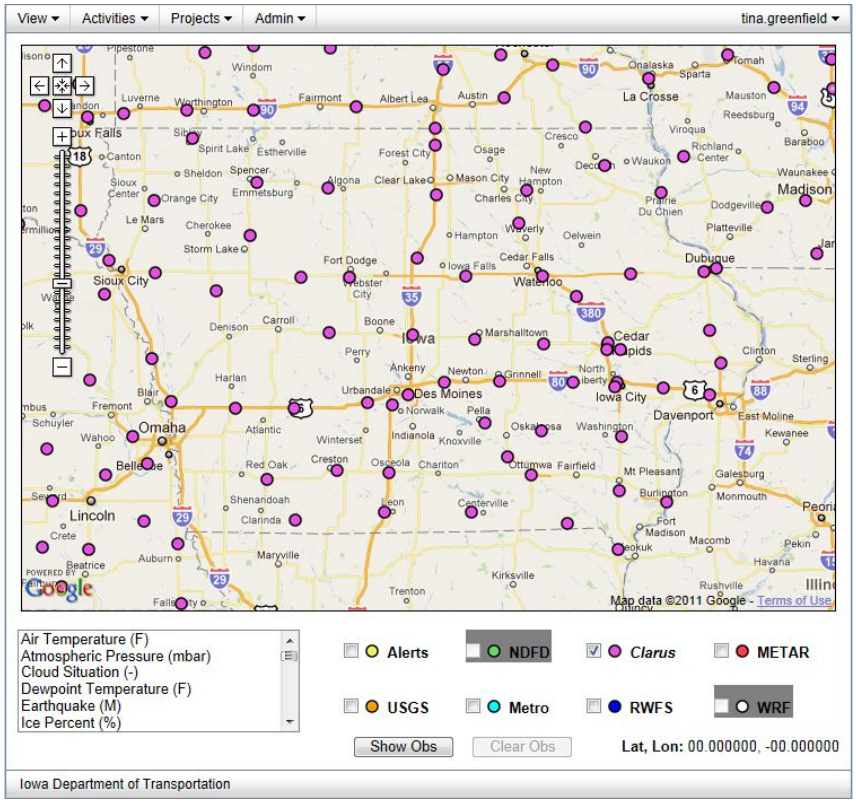
The tool assists agencies in disseminating information about their advisory and control decisions to partnering agencies in a timely manner. It allows decision-makers in one state to have full knowledge of, and access to, the latest advisory and control information deployment decisions made by other states and/or entities. Agencies believe that improved access to such information will facilitate coordination of responses and more timely dissemination of roadway condition information to travelers, thereby improving overall safety while mitigating the impacts of weather events on travelers. Furthermore, the tool has the potential secondary benefit of improving the efficiency of the decision-making process by improving the level of access and timeliness that individuals have to key factors that could potentially impact their decisions.

To demonstrate the potential benefits that can be derived though improved coordination between agencies during weather events, FHWA's Road Weather Management Program (RWMP) commissioned the development of the MSCST. Designed and developed by Mixon Hill, Inc., the tool provides multiple users with different levels of access to weather data provided by the *Clarus* system. The tool also allows agencies to better coordinate their response strategies within and between different jurisdictions by facilitating the dissemination of weather and traffic management advisory and control strategies deployed as weather

conditions change. Through the tool, users have access to multiple types of weather information provided by multiple sources including the following:

- Maps showing current weather observation data from stations located throughout various states and/or regions.
- National Weather Service (NWS) radar images showing precipitation intensities for an agency's geographic region.
- Satellite map images showing three types of satellite imagery (infrared, visible, and water vapor) from geostationary satellites.
- NWS warnings, watches, and advisories for the state at the current time.

Figure 1 shows an example screen capture of the *Clarus* weather observation data for Iowa. From this screen, the user can select the weather observations (such as air temperature, atmospheric pressure, etc.) of interest and the tool will then populate the screen with the desired observations from all the stations. Users also have the ability to select other sources of weather information from the weather observation screen.



Source: MSCST Screen Capture

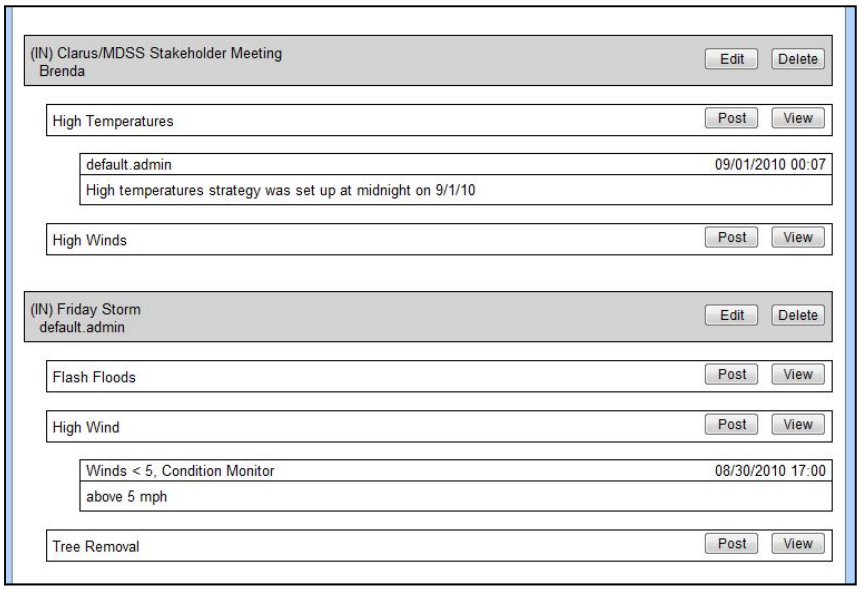
Figure 1. Locations of Weather Monitoring Stations Available through MSCST in Indiana

The tool enables coordinators and responders within agencies to establish and participate in "conferences." These conferences provide a common work area to monitor and post information about situations and responses to specific weather events. Conferences consist of individual subscribers who 1) want information about a common weather event or 2) whose decisions during a particular weather event may be impacted by the decisions of others also responding to the same weather event. The tool allows users to setup "strategies" for monitoring evolving weather conditions within a conference. Strategies compare observed weather data from the sources listed above against user-defined criteria. When observed conditions exceed the thresholds established by the agency, the tool issues an alert to the users and posts a message to all participants in the conference. Users can define multiple criteria for each strategy. In addition to monitoring for changes in observed weather conditions, the users can also specify actions that can be taken as part of the tool's monitoring function. This option might include the following actions:

- Creating a new strategy within a conference and associating the current monitoring criteria to the new strategy.
- Appending a predefined alert message when the observations are determined to meet the monitoring conditions.

The tool also allows other users to view and/or post messages directly to the system. This feature allows users within the same agency or between different agencies to coordinate deployed responses.

Figure 2 shows an example of what a user might see in a "conference" window. This particular window shows two conferences (indicated by the gray rectangles) with several strategies (e.g., High Temperatures, High Winds, Flash Floods, etc.) under each conference. The figure also shows an alert that was triggered by the weather condition monitor that was established under the "High Wind" strategy in the "Friday Storm" conference. This alert was triggered when the measured conditions exceeded the threshold established by user (e.g., Winds above 5 mph).



Source: MSCST Screen Capture

Figure 2. Example Conferences Established in MSCST

For testing purposes, the following agencies deployed the MSCST on a limited basis: the Iowa DOT, the Illinois DOT, and the Indiana DOT. Iowa DOT and IDOT both agreed to participate in the evaluation of the MSCST.

The conferences used in the evaluation were intended to take advantage of the weather monitoring and alert notification capabilities of the tool. As part of these conferences, each agency established strategies that would alert members of changing observed weather conditions (such as high winds, limited visibility, snow and ice accumulation, extreme precipitation, and extreme temperatures). Each agency established its own threshold conditions that would trigger an alert associated with a particular observed weather condition. The MSCST would alert (via email and/or text message) the subscribers to the conference when a specific weather condition threshold had been met.

Table 1 shows the strategies used by Iowa DOT and IDOT during the evaluation period. Table 2 shows the thresholds that were established for triggering alerts for each strategy. Table 3 shows the thresholds used to discontinue or remove the alert for each strategy.

Table 1. Strategies Used by Each Agency in Evaluation of MSCST

Evaluation Strategy	Iowa DOT	IDOT
Frost Warnings	✓	✓
Blowing Snow Warnings	✓	✓
Precipitation on Cold Pavement	✓	✓
Slick Road Warning	✓	✓
Limited Visibility Warning		✓
High Wind Warning		✓
Precipitation Rates		✓

Table 2. Thresholds Used to Issue or Establish Alerts for Each MSCST Strategy

Evaluation Strategy	Threshold*	Alert Message
Frost Warnings	Surface Temperature ≤ 34°F AND Dewpoint Temperature ≥ Surface Temperature	"Potential Frost Development Risk"
Blowing Snow Warnings	Surface Status = "Slush" AND Avg. Wind Speed > 15 mph	"Blowing Snow Potential – HIGH"
Precipitation on Cold Pavement	Precipitation ≠ "None" AND Pavement Temperature ≤34°F	"Precipitation occurring on cold pavement"
Slick Road Warning	Surface Status ≠ "Dry" AND Air Temperature ≤ 34°F	"Roadway likely to begin getting slick"
Limited Visibility Warning	Visibility ≤ ¼ mile	"Post DMS message regarding poor visibility."
Surface Status	Surface Status = "Frost" OR "freezeAdvisory" OR "slushAdvisory" OR "iceAdvisory" OR "freezeHazard" OR "Ice"	"Notify travelers that driving conditions are hazardous due to winter weather via DMS. Verify that maintenance crews are aware of weather conditions."
High Wind Warning	Average Wind Speed > 25 mph	"Notify high profile vehicles of strong winds via DMS. Notify motor carrier services of high winds for other means of message dissemination."
Precipitation Rates	Precipitation Rate > 2 in. per hour	"Notify travelers via DMS of hazardous driving conditions due to heavy rains."

*The weather parameters used to assess the evaluation strategy conform to the definitions used in the *National Transportation Communications for ITS Protocols Environmental Sensor Station Interface Standards* (NTCIP 1204 v02-19), August 2004.

Table 3. Thresholds Used to Discontinue Alerts for Each MSCST Strategy

Evaluation Strategy	Threshold*	Alert Message
Frost Warnings	Surface Temperature > 34°F OR Dewpoint Temperature < Surface Temperature	"Frost Development Potential Diminished"
Blowing Snow Warnings	Surface Status ≠ "Slush" OR Avg. Wind Speed ≤ 15 mph	"Blowing Snow Potential – REDUCED"
Precipitation on Cold Pavement	Precipitation = "None" OR Pavement Temperature >34°F	"Precipitation on cold pavement – threat diminished"
Slick Road Warning	Surface Status = "Dry" OR Air Temperature > 34°F	"Precipitation should be clear or melting."
Limited Visibility Warning	Visibility > ¼ mile	"Remove DMS messages."
Surface Status	Surface Status ≠ "Frost" AND "freezeAdvisory" AND "slushAdvisory" AND "iceAdvisory" AND freezeHazard" AND "Ice"	"Verify that driving conditions are better, then remove DMS messages."
High Wind Warning	Avg. Wind Speed ≤ 25 mph	"Remove notifications."
Precipitation Rates	Precipitation Rate ≤ 2 in per hour	"Remove DMS message."

*The weather parameters used to assess the evaluation strategy conform to the definitions used in the *National Transportation Communications for ITS Protocols Environmental Sensor Station Interface Standards (*NTCIP 1204 v02-19), August 2004.

3 Evaluation Approach

The primary focus of Use Case #4 tool is to improve coordination between agencies within a region. It is not intended to be a tool to disseminate information directly to the public. Therefore, the objective of the evaluation was to assess whether and how coordination between agencies during weather events improved because of using the tool. Tool users included the state and local DOTs and emergency service providers that used the tool to access weather and/or roadway condition alerts. These agencies have a strong need for coordinating responses and sharing information in planning and deploying advisory and control responses and actions in response to changing weather conditions.

3.1 Evaluation Setting

Two state DOTs agreed to participate in the evaluation of the MSCST in an operational setting: Iowa DOT and IDOT. The primary geographic area where the tool was deployed was the Quad Cities region on the Iowa/Illinois boundary. The Quad Cities region includes the cities of Davenport and Bettendorf in Iowa, and the cities of Moline and Rock Island in Illinois. Interstates I-80, I-74, and I-280 are the primary highways that run through the Quad Cities region, each with a major bridge crossing over the Mississippi River connecting both states. I-74 connects the City of Moline, Illinois with the City of Bettendorf, Iowa through the center of the region. I-280 is part of a loop/bypass to the south and west of Davenport, Iowa and Rock Island, Illinois. I-80 bypasses the region to the north and east of the Bettendorf, Iowa, and Moline, Illinois. Another major bridge, located on US-67 connects the City of Rock Island, Illinois with the City of Davenport, Iowa. Figure 3 shows an overview of the region.

Source: MapQuest.com

Figure 3. Region Selected for Evaluating the MSCST

The state DOTs and the evaluation team selected this region for testing the MSCST for the following reasons:

- The Quad Cities region allows the evaluation team to examine inter-jurisdictional communications and cross-state communications in a well-defined area.
- The region already has a solid foundation of interagency coordination and cooperation. Many of the stakeholders know each other and routinely interact with one another during weather and other events that impact operations in the region.
- The Quad Cities is a small enough area to permit the formation of meaningful conferences that can deal more effectively with a severe weather event that might impact this region.
- Many different agencies in the region could potentially benefit from using this tool to improve the management of traffic and incidents during weather conditions.

3.2 Evaluation Design

The primary overall purpose of the evaluation was to document the benefits of the MSCST in terms of improved coordination between agencies during weather events. A secondary purpose of the evaluation was to document lessons learned and to help guide development and deployment of the MSCST past the demonstration phase.

The evaluation relied on collected "stated preference" data (i.e., statements about how agencies anticipate using the system or their perceptions of the system) to assess how the tool can be used by agencies to improve their coordination with other agencies. While some information about usage was collected, information about "revealed preferences" was not collected as part of this evaluation. Revealed preferences refer to information obtained based on observations of uses and subsequent effects on advisory and control decisions made by agencies in response to the recommendations provided by the tool.

3.2.1 Objectives and Hypotheses

The research team identified two overarching objectives of the evaluation study:

- To assess the degree to which inter-agency cooperation and coordination could be improved through the sharing of accurate and timely weather data and response information during weather events.
- To assess the degree to which agencies could be more proactive in their traffic management advisory and control responses during weather events by having access to accurate and timely weather information provided by *Clarus*.

For these evaluation objectives, the evaluation team developed the following four evaluation hypotheses:

Evaluation Hypotheses #1: Having access to accurate and timely weather information through the MSCST helped agencies proactively respond to changing roadway and travel conditions resulting from changing weather conditions.

A key assumption for this use case is that more regional level based (as opposed to county level based) access to weather-related data will allow transportation agencies to make better, faster decisions about advisory and control traffic management strategies. Also, knowing how other agencies are responding (or planning on responding) to developing weather events will help each individual agency be more effective/proactive in managing traffic operations in its jurisdiction under evolving weather conditions. Proactively managing traffic operations is anticipated to produce reductions in unsafe conditions and crash potential.

The data used to test each of these hypotheses were derived from interviews collected by the evaluation team at the conclusion of the evaluation period. Specific interview questions were directed at users to obtain their perceptions of the tool's effectiveness. Specific measures of effectiveness used to test this hypothesis included the following:

- Number of users (subscribers) indicating that they believe the MSCST improved the level of coordination and cooperation between agencies.
- Number of users (subscribers) indicating that they believe the MSCST helped them manage weather events proactively.
- Number of users (subscribers) indicating that having access to current weather information through the MSCST tool improved their decision-making capabilities.

Evaluation Hypothesis #2: As a result of using the MSCST, agency responses to weather-related events are better coordinated.

Having better access to developing and evolving weather conditions allow users to be better prepared when weather and roadway surface conditions begin to deteriorate. With better access to weather information and information about how other agencies are responding, agencies have the potential to reduce the number of weather-related collisions, reduce the number of weather-related rescues, and reduce the number of "trapped" or abandoned vehicles.

As in testing the previous hypothesis, the approach used included case studies and interviews on how agency perceptions about level of coordination between agencies changed after using the tool. Agencies were asked to rate their level of coordination with other agencies after using the tool compared to before using the tool. These comparisons allow determination of how the level of coordination changes over time. The specific measures of effectiveness used to assess the MSCST at improving the coordination between agencies in weather-related events included:

- The number of users (subscribers) indicating that having access to the information provided in the MSCST helped them reduce congestion caused by weather events.
- The number of users (subscribers) indicating that having access to the information provided in the MSCST helped them improve safety during weather events.

Evaluation Hypothesis #3. Because of using the MSCST, agency responses to weather-related events are more timely and appropriate.

Being able to respond to changing weather conditions quickly and appropriately is critical to minimizing the adverse effects of weather on traffic operations and safety. The MSCST provides agencies with timely and accurate information about weather conditions. FHWA believes that agencies can be more proactive in their responses to weather if they have timely and accurate weather information.

Data to test this hypothesis came primarily from interviews with agency personnel on their ability to make same day decision changes. The measures of effectiveness of the MSCST was the number of users (subscribers) indicating that the MSCST provided them with timely and accurate information that facilitated proactive responses to weather events.

Evaluation Hypothesis 4. State DOTs view the MSCST as useful and beneficial for improving coordination between agencies during weather events**.**

By using the tool, the state DOTs are able to be more flexible in their decision-making, thereby allowing them to make more informed operational and planning decisions. Data to test this hypothesis came from interviews with agency personnel on their ability to make same day decision changes. The measure of effectiveness used to assess this hypothesis was the level of agency satisfaction with the tool.

3.2.2 Data Collection

The evaluation consisted of three data collection efforts. The first involved collecting general usage statistics and tracking these over time to see how use of the tool changed as users became more familiar with the tool. Second, the evaluation team used a tabletop exercise and focus group interviews to assess potential ways coordination between agencies could be improved by using the MSCST during an incident condition. The final data collection effort involved conducting interviews with agency personnel to collect data on their perception of the potential usefulness and value of having the MSCST available to assist them in coordinating the deployment of advisory and control strategies during weather events. Each of these data collection efforts is discussed below.

3.2.2.1 General Usage Statistics

This effort involved collecting general usage statistics detailing how the subscribers utilized the tool during specific weather events. Usage statistics were tracked over time to determine how the use of the tool by the agencies changed as a function of subscribers' increased familiarity with the tool. The evaluation team members were added to each of the agencies' conferences that they established. This allowed the evaluation team to receive alerts issued by each agency within each strategy. The alerts were then used to generate usage statistics.

As part of the evaluation effort, the evaluation team attempted to track the following usage statistics from real weather events:

- The number of subscribers in each conference per month.
- The number of new subscribers added to each conference each month.
- The number and types of strategies in each conference that were activated each month.
- The number and types of new strategies added in each conference each month.

- The number and types of strategies in each conference that were modified each month.
- The number and types of advisory actions requested by one agency of another agency in response to weather events.
- The number and types of control actions requested by one agency of another agency in response to weather events.
- The number and types of advisory actions requested by one agency implemented by another agency in response to weather events.
- The number and types of control actions requested by one agency and implemented by another agency in response to weather events.
- The time differential between the initial control action requests sent by one agency to the implementation of the action by the other agency.
- The time differential between the initial advisory action requests sent by one agency to the implementation of the action by the other agency.
- The number (and severity) of known weather-events where no conferences were initiated.

3.2.2.2 Tabletop Exercise

Because there was concern by the product developers, the state DOTs and the evaluation team about having incident response agencies work with an untested tool in an actual response situation, and because there was no guarantee that an incident situation in which weather might change the response would occur during the evaluation period, the evaluation team, at the request of the local agencies, developed a tabletop exercise designed to test the *potential* of the tool for improving agency response during incident conditions. The tabletop exercise involved devising a hypothetical incident situation in which weather conditions might change how agencies responded to the incident. The scenario involved an over-turned tanker truck leaking a hazardous cargo in a major interchange just outside of the Quad Cities area. Both transportation and emergency incident response agencies (local fire, police, and transportation agencies) were involved in the exercise. Participants were given information about the hypothetical incident and evolving weather conditions using the MSCST. At the conclusion of the hypothetical event, the research team facilitated a focus group discussion to assess the participating agency's perceptions of the usefulness and benefit of the MSCST in developing traffic management responses to the scenario. Appendix A contains the protocol that was followed in conducting the exercise.

3.2.2.3 Agency Interviews

At the end of the evaluation period, the evaluation team also conducted interviews of the MSCST users (subscribers) to assess their perceptions of the usefulness and the benefits of having the MSCST to assist them in developing and coordinating weather-related advisory and control traffic management strategies. As part of these interviews, subscribers were asked to provide their perceptions of the usefulness, timeliness, and accuracy of the information provided by the tool. Users were also asked to comment on how agency practices, procedures, and responses to weather events potentially *could* be changed because of using the MSCST.

One-on-one interviews were conducted with one user from the Iowa DOT and two users from the IDOT. In these interviews, the evaluation team asked open-ended questions to allow the users to express their ideas and comment. Appendix B contains the protocol and interview questions that were followed in the agency interviews.

3.3 Data Analysis

The data analysis for the evaluation is fairly straightforward. Comments received during the discussion of the tabletop exercise were aggregated and summarized. Similarly, responses obtained by the agency users in the interview process were also aggregated and summarized. To comply with Texas A&M University's Institutional Review Board requirements, the names and identify of the interviewee's were removed. Usage statistics were generated by looking at the content of each email alert produced by the system.

4 Evaluation Findings

This section presents the findings of the evaluation. The results of the usage statistics collected from November 2010 to early February 2011, followed by the findings from the table top exercise. The tabletop exercised occurred in October 2010. Agencies interviews were conducted in early March 2011.

Table 4 provides a summary of the hypotheses tested as part of this evaluation study and the results of those tests.

4.1 Usage Statistics

Usage statistics were collected throughout the duration of the evaluation period for both the Iowa DOT and IDOT established conferences. The tool was deployed for almost three months in each of the locations, beginning in the third week of November 2010 and lasting through first week in February 2011. The following sections show frequencies and types of messages and responses logged by the system for each agency during the evaluation period.

4.1.1 Iowa

During the evaluation period, a total of 322 alerts were issued by the MSCST. However, a review of the individual alerts revealed that multiple alerts were issued when the potential existed for a single frost event to occur. In looking at individual frost warning alerts, the evaluation team noticed that, for example, if the evaluation logs indicated that a frost alert was issued because the surface temperature dropped below 30°F, the tool actually produce five alerts (an alert for the surface temperature being below 34°F, below 33°F, below 32°F, below 31°F and below 30°F) for the same frost event. Therefore, when a potential for a frost alert occurred, the MSCST received multiple alerts for the same event, and so accounting for the fact that multiple alerts were issued for the same frost event, the evaluation team concluded that the tool produced alerts for a total of 251 different weather events.

Figure 4 shows the number of alerts issued per day for each month of the MSCST implementation in Iowa, while Figure 5 shows the number of alerts issued each day by the MSCST. The evaluation period ran from November 19, 2010 through February, 5, 2011.

Table 4. Summary of Results of the Use Case #4: Multi-State Control Strategy Tool Evaluation Study

Hypotheses	Evidence	Level of Support
Having access to accurate and timely weather information through the MSCST helped agencies proactively respond to changing roadway and travel conditions resulting from changing weather conditions.	• The tabletop exercise revealed that field personnel are not likely to take the time to use the tool to enter and extract weather information. Field personnel need to know when and for how long weather will be impacting response. • Agency interviews revealed that significant modifications are needed with respect to the manner in which weather information is presented. Responders preferred processed weather information over general observation data.	Minimal Support
As a result of using the MSCST, agency responses to weather-related events are better coordinated.	• Use statistics and agency interviews suggest that the tool did not improve coordination between agencies. In the test areas, the response agencies already have clearly identified and strong lines of communication. During weather events, agencies preferred to use these trusted lines of communication over the MSCST. The telephone is the primary tool of choice for coordinating responses.	No Support
Because of using the MSCST, agency responses to weather-related events are more timely and appropriate	• Usage statistics and agency interviews suggest that the tool was not used by agencies to improve the timeliness of responses to weather events. The tested configuration of the tool supported only a limited number of weather event configurations used to trigger alerts (4 in Iowa, and 6 in Illinois). Significant revisions to the event trigger decision-making are needed to improve the level of sophistication of the triggers.	No Support
State DOTs view the MSCST as useful and beneficial for improving coordination between agencies during weather events.	• Results for agency interviews revealed that significant modifications are needed to the MSCST to improve its usefulness in coordinating responses between agencies. These improvements include providing capabilities to search for responses, providing map overlay showing the latest response/action taken by operators, and setting milestones so that the current status of an event can easily be determined. • With some revisions, the tool could be used as a resource tracking tool to let agencies know the availability of resources, particularly that status of personnel (who as on-duty and who was off-duty), contact information, etc. during weather events.	Minimal Support

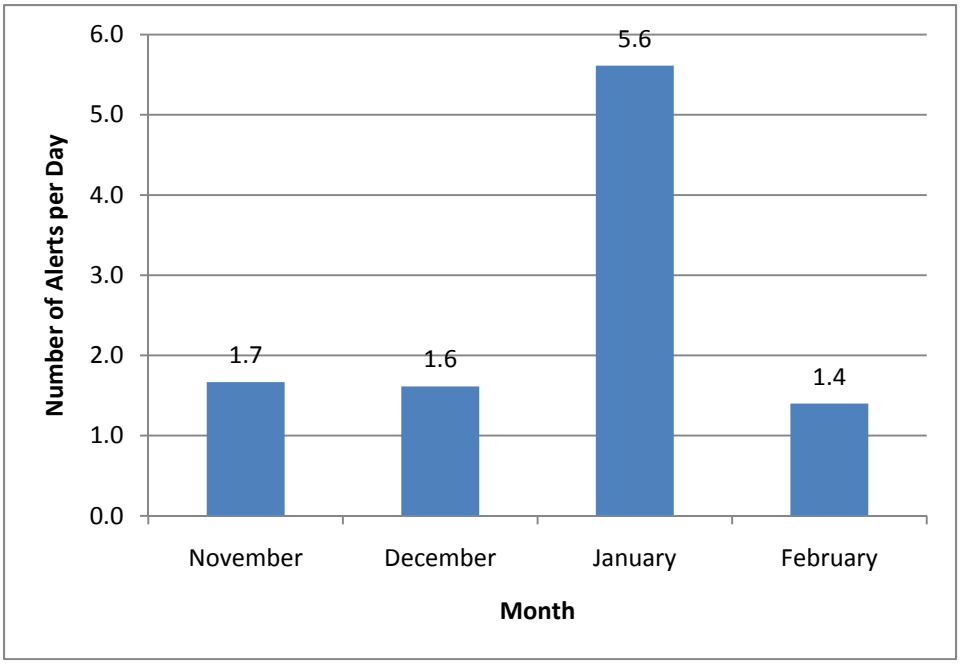


Figure 4. Distribution of Alerts Produced by the MSCST in Iowa during the Evaluation Period

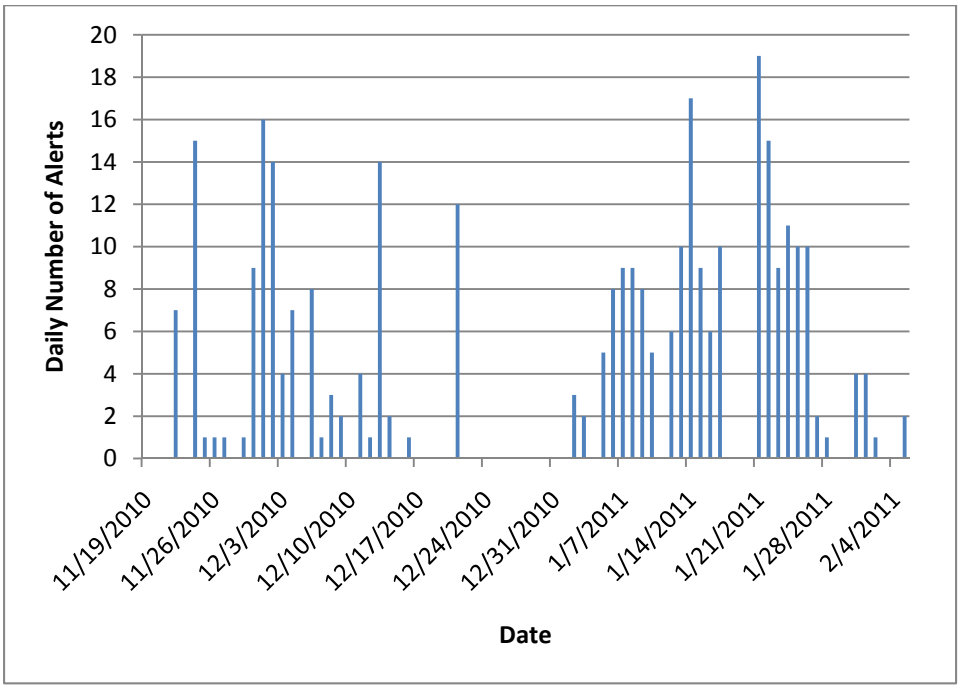


Figure 5. Daily Number of Alerts Issued in Iowa Evaluation Section during the Evaluation Period

As shown in Figure 4, there were over 3 times as many alerts issued in the month of January compared to December. A review of the individual alert records showed that MSCST issued the following alerts:

- A "Precipitation on Cold Pavement" alert occurred at 6:17 PM on 12/16/2010 that was not cleared until 4:50 PM on 1/1/2011. The total duration of this alert was 15 days, 22 hours, and 33 minutes.
- A "Slick Road Warning" alert occurred at 6:17 PM on 12/16/2010 that was not cleared until 4:50 PM on 1/1/2011. The total duration of this alert was 15 days, 22 hours, and 33 minutes.
- A "Frost Warning" alert occurred at 10:21 AM on 12/21/2010 that was not cleared until 4:50 PM on 1/1/2011. The total duration of this alert was 11 days, 6 hours, and 29 minutes.
- A "Blowing Snow Warning" alert occurred at 10:21 AM on 12/21/2010 that was not cleared until 4:50 PM on 1/1/2011. The total duration of this alert was 11 days, 6 hours, and 30minutes.

The evaluation team does not know why these alerts during this particular time lasted for such a long duration, but according to the National Climatic Data Center (NCDC), a major snowstorm hit the area on 12/12/2011, and significant snow accumulation (3 to 8 inches) also occurred during this period (from 12/12/2010 to 12/31/2010). The evaluation team was unable to determine whether the conditions that triggered this alert persisted for the entire duration of these alerts or whether a malfunction occurred either with the weather sensing stations feeding the MSCST or with the MSCST itself.

Figure 6 shows the distribution of the types of alerts that were issued by the MSCST in the Iowa deployment throughout the evaluation period while Figure 7 shows the distribution of alerts by type for each month the tool was used in Iowa. Half of the alerts were issued because precipitation was detected on cold pavement, while 42 percent were "Slick Road Warning" alerts (see Table 2 for definitions used). In total over 92 percent of the alerts were related to some type of precipitation present on the pavement with the ambient air temperature approaching the freezing point.

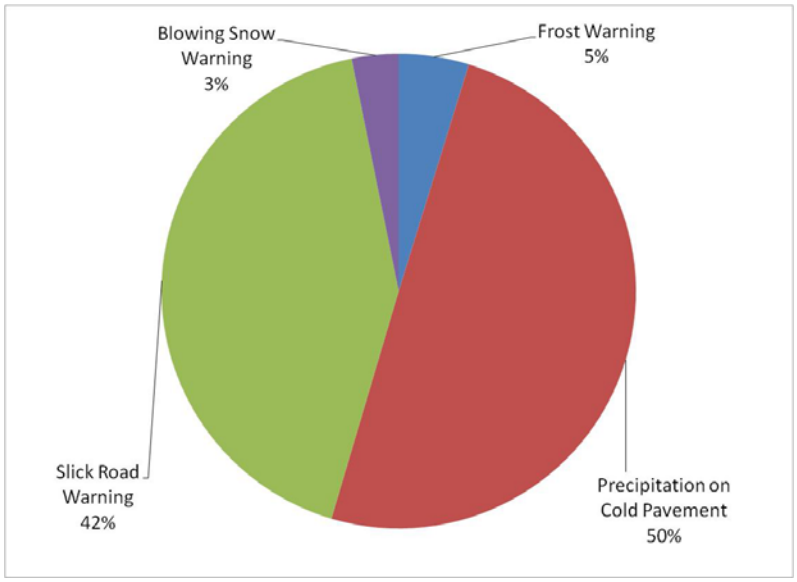


Figure 6. Distribution of Types of Alerts Issued by MSCST in Iowa for the Entire Evaluation Period (11/19/2010 through 02/05/2011)

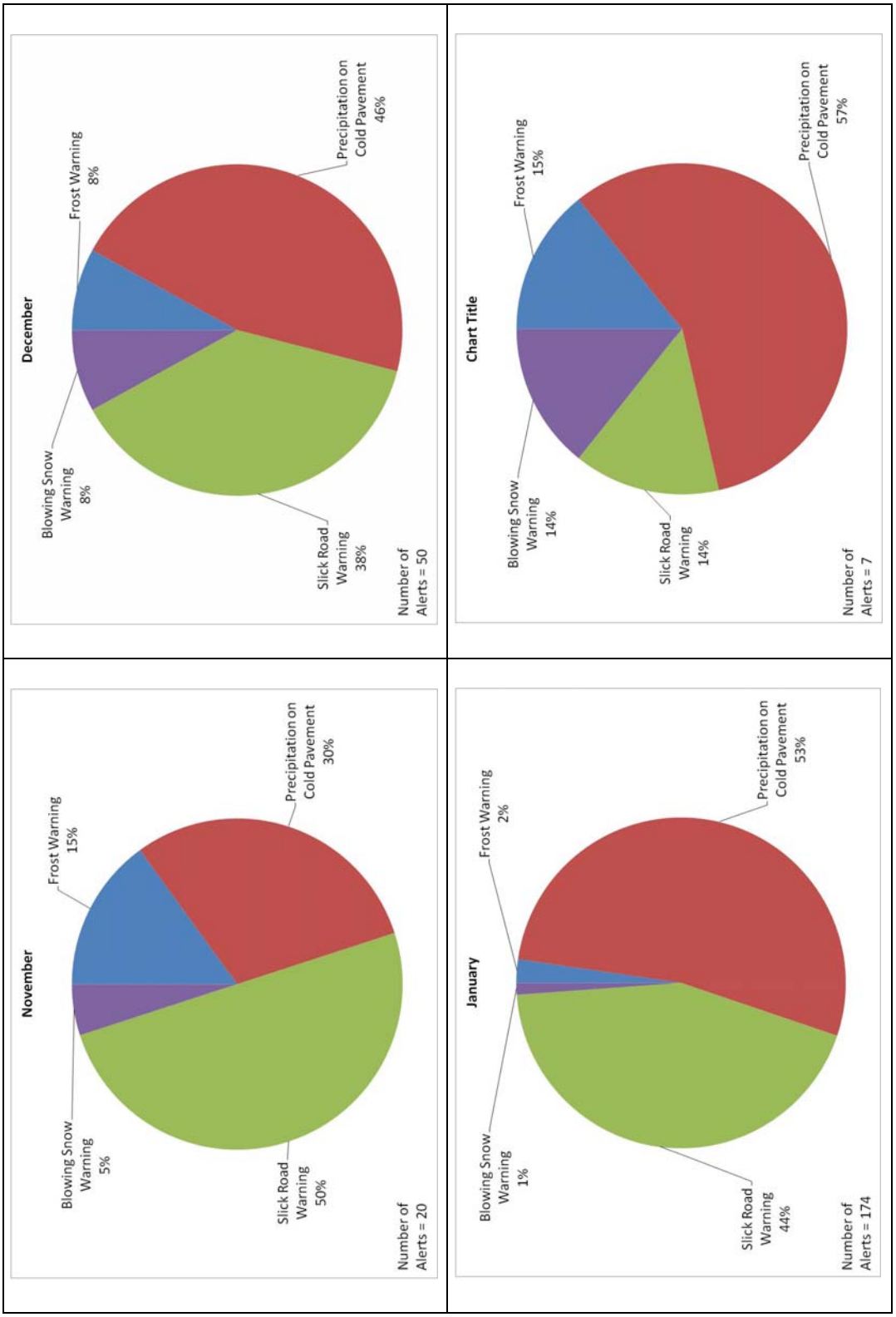


Figure 7. Distribution of Types of Alerts Issued by MSCST in Iowa for Each Month of the Evaluation Period

During the evaluation period, Iowa DOT did not add any new subscribers nor were any new strategies or conferences added by Iowa DOT during the evaluation period. The reasons cited for not adding any new subscribers to the system were twofold: 1) the tool had not been tested enough to the point where Iowa DOT felt comfortable with wide scale use of the tool, and 2) the process of adding new subscribers to the system was difficult and cumbersome. Also, initial issues related to the establishment of alerts and alarms (e.g., because the initial thresholds for the frost warning system were configured incorrectly, they caused numerous false alarms during the early phase of the deployment in IA) might have reduced Iowa DOT's comfort level with the tool and willingness to deploy the tool widely in their organization.

Iowa DOT did not add any new strategies or conferences during the evaluation period. Again, the reason cited for not adding any new strategies or conferences was the complexity of the tool. Agencies reported that establishing conferences and associated strategies in the tool was difficult and needed to be simplified. Another possibility is that the tool was not deployed long enough to allow agencies to become familiar with the process for changing or adding new strategies and did not identify needs of alerts other than what was established for them for the initial evaluation period.

Iowa DOT also reported that they did not take any action based upon the alerts provided by the tool. Based on the conferences reviewed by the evaluation team, no indication can be found where traffic management advisory or control strategies were implemented in response to an alert that was received by Iowa DOT. One possible explanation for this is that in the post-deployment interviews, Iowa DOT indicated that during a weather event, system operators and field personnel are extremely busy and do not have time to monitor a system for receiving alerts. Iowa DOT also indicated that they currently have other tools that are more powerful and accurate at providing alerts during weather conditions. Currently, Iowa DOT uses an RWIS management system that permits weather-related alerts to be developed. This system allows for more conditions to be tested and provides greater flexibility in developing alerts for different types of weather conditions than does the tested version of the MSCST.

4.1.2 Illinois

In the Illinois test area, the MSCST issued a total of 312 alerts covering 259 different weather events during the evaluation period. As in Iowa, multiple alerts were issued for each frost warning conditions because the tool was not designed to support nested decision rules. Unlike in Iowa, the alerts were evenly distributed between December and January, with a total of 109 and 128 weather-related alerts being issued by the tool in December and January, respectively. Figure 8 shows the distribution by month of alerts issued by the tool.

Figure 9 shows the distribution of alerts issued each day during the evaluation period (11/19/2010 through 2/5/2010) in the Illinois evaluation area. The figure shows that there was a significant portion of the evaluation period (from 1/2/2011 to 1/12/2011) when the MSCST did not issue any alerts. The Preliminary Record of Climatological Observations available through the NCDC for the Moline, Quad City International Airport showed that the area experienced some significant weather during this period that was consistent with the alerts established by the IDOT. The evaluation team could not determine the reason why the MSCST did not produce any alerts during this time.

Figure 10 shows the types of alerts issued by the MSCST in the Illinois test area. Figure 10 shows that over the whole evaluation period, approximately 40 percent were in response to limited visibility conditions, 21 percent of the alerts were slick road warning alerts, and 17 percent were precipitation on cold pavement alerts.

Again, these alerts seem reasonable given the Climatological Observation data; however, upon further review of the alert types issued by month a slightly different picture emerges.

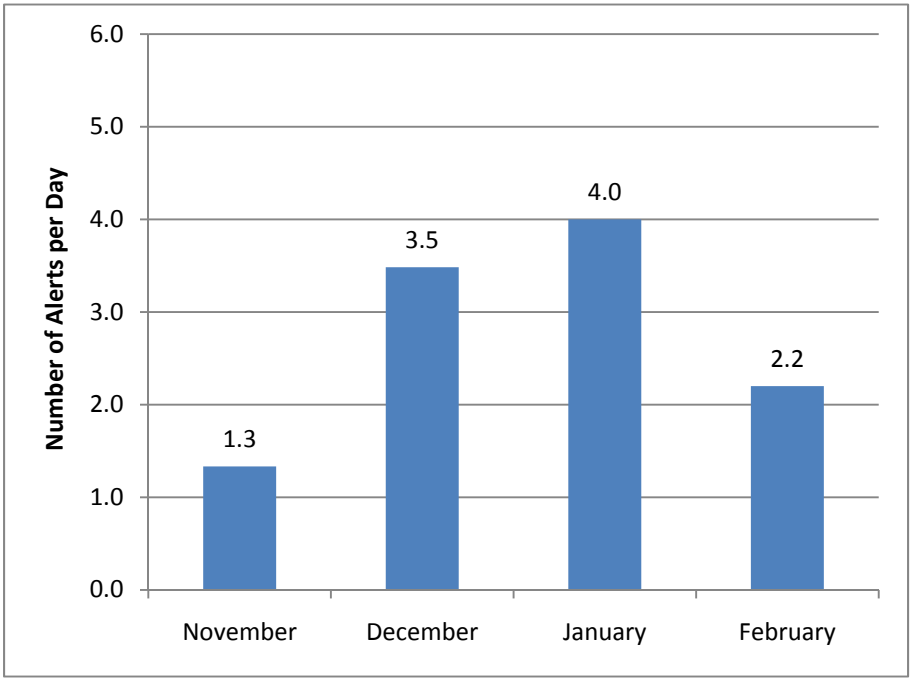


Figure 8. Distribution of Alerts Produced by the MSCST in Illinois during the Evaluation Period

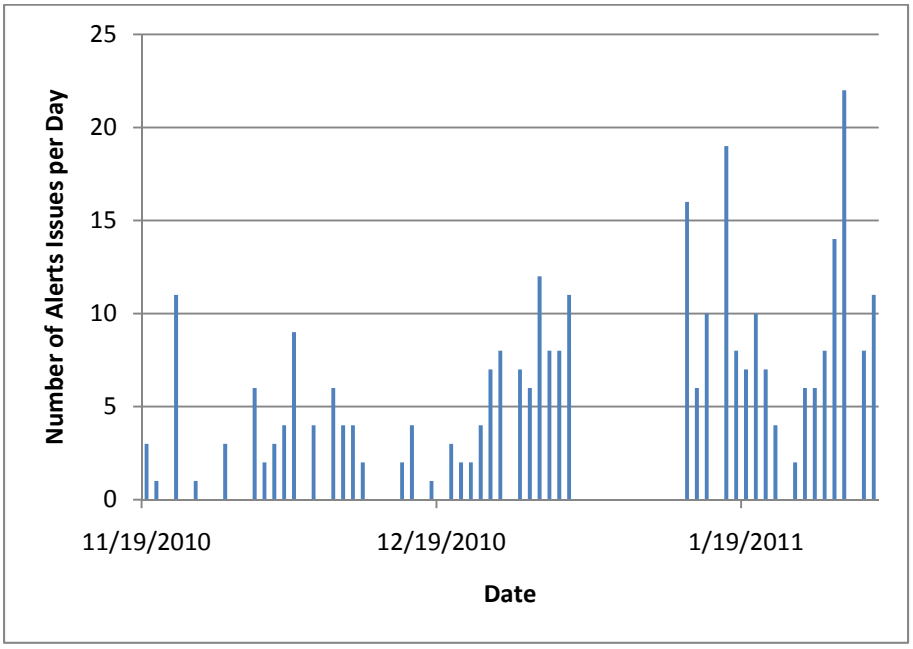


Figure 9. Number of Alerts Issued per Day in Illinois Evaluation Section

Figure 11 shows how the alerts broke down each month. During the early months of the evaluation, "Slick Road Warning" represented almost half the alerts produced by the system. This seems to make sense, since during the late part of the fall and early part of the winter, most precipitation occurred as rain. However, during January, over two-thirds of the alerts produced by the system were limited visibility alerts. The evaluation team was unable to confirm or deny that limited visibility conditions truly existed in the Illinois evaluation area during this time. A review of the individual alerts revealed that during the month of January, the system produced a "visibility" alert approximately every 3 hours. The regular frequency of the alerts suggests that an issue may have existed either with the tool itself or the sensor data used by the tool to issue alerts.

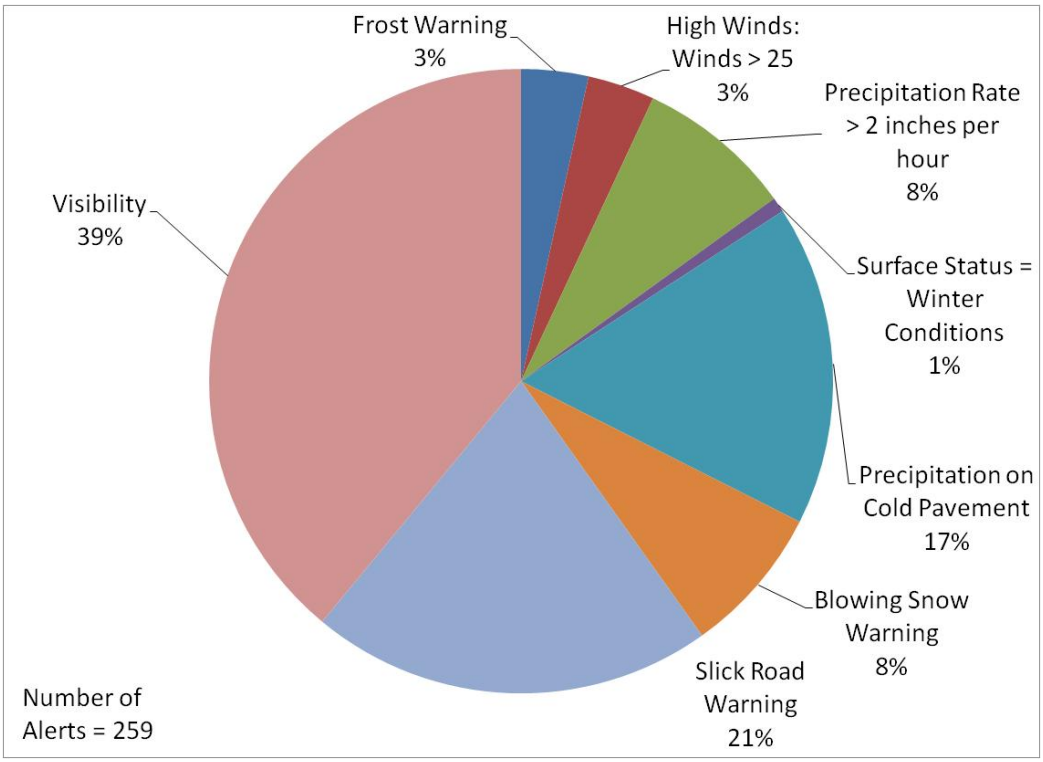


Figure 10. Distribution of Types of Alerts Issued by MSCST in Illinois.

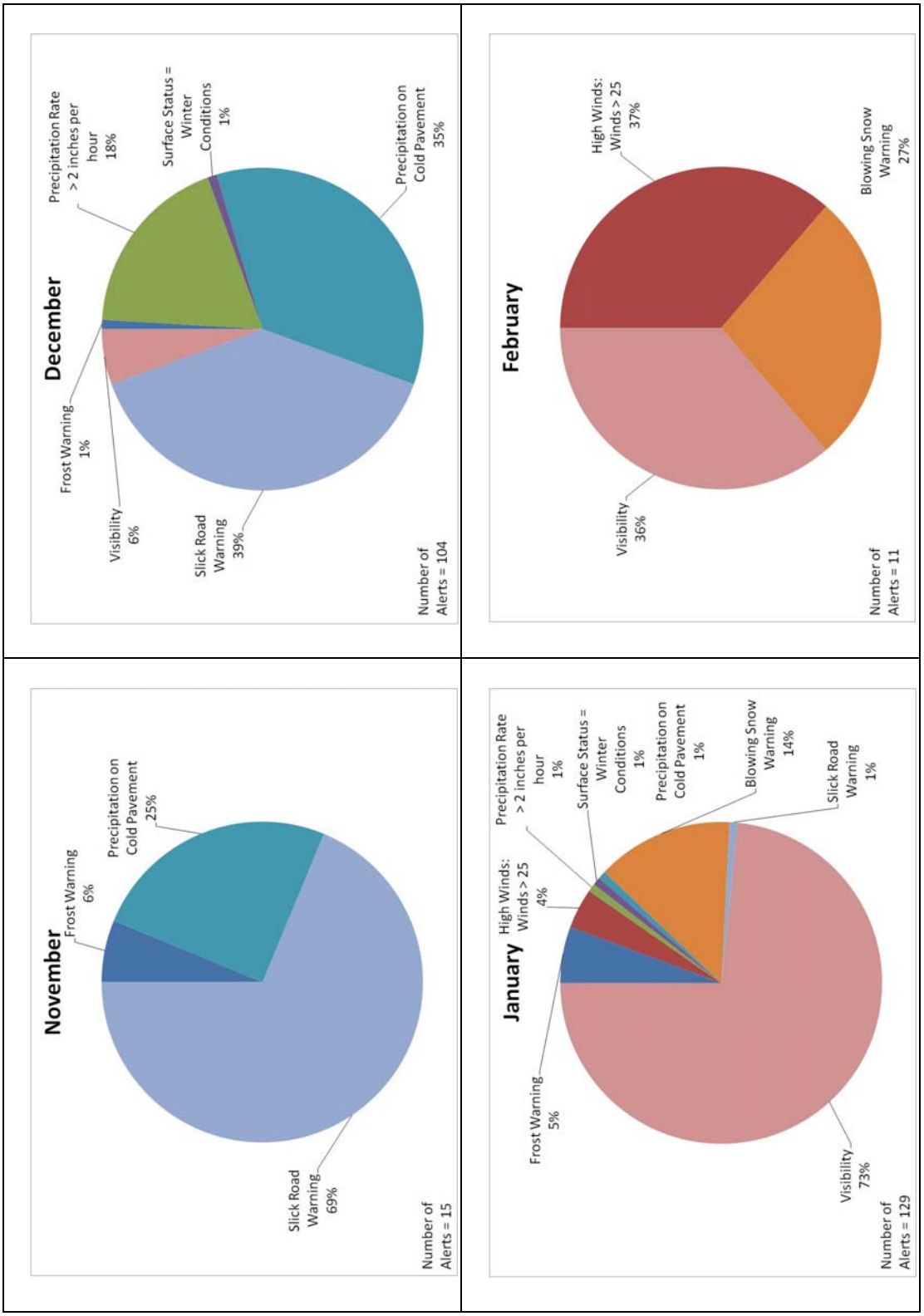


Figure 11. Distribution of Types of Alerts Issued by MSCST in Illinois for Each Month of the Evaluation Period.

4.2 Tabletop Exercise Focus Group

As discussed in Section 3.2.2.2, the evaluation team conducted a tabletop exercise to investigate how the tool might be used to improve coordination between agencies during an incident condition. In the tabletop exercise, incident responders from the Quad Cities area were provided with simulated weather alerts through the MCSCT as they discussed their response to a hypothetical overturned tanker truck that was leaking part of its load. Then through a facilitated discussion, the responders were asked to comment on how having access to weather information might be beneficial as they planned and executed their response. The organizations represented in the tabletop exercise included the following:

- Local representative from both the Iowa and Illinois Highway Patrols.
- District operations and maintenance personnel from both Iowa DOT and IDOT.
- Iowa DOT representatives from the Iowa Statewide Emergency Operations Team.
- Local and county law enforcement and fire department personnel from the cities of Moline, IL; Rock Island, IL, Davenport, IA; and Bettendorf, IA.

Listed below are the major findings from the focus group discussion after the exercise:

- Field personnel do not have time to enter information and monitor alerts during the initial portion of an incident response. During the early stages of a response, incident responders are worried about securing the scene, providing first aide and attending to injuries, assessing the scene, and establishing traffic control. The ideal place for a tool like the MSCST would be the dispatch center. Here operators could monitor weather changes and alerts and forward them to field responders when appropriate or requested by the on-scene commander.

- The tool could be valuable as an on-scene tool for keeping a log of all the responses that occur at the incident scene. This would only occur with large, long-term incidents in which the Incident Commander (under the Unified Incident Command Structure) would assign someone to be the “scribe” for the incident. The scribe’s sole responsibility would be to record all the activities that occurred. The information collected, if the tool was used in this manner, would be valuable for an “after-action” review.

- Generally, long-term incidents (such as this one with an overturned truck) enter into a “maintenance” mode. This occurs after the scene has been secured and the response is well established. It is at this time that field responders might have the luxury to actively monitor weather conditions.

- The tool provided a lot of information in a short period of time and required a lot of input from the users. There were concerns about information overload. The tool needs to be greatly simplified and better integrated into their existing tools if it is to see widespread deployment. Users need a way to sort by different criteria. For example, it would be helpful if a user could sort by response type or by response group. Currently, the only way to search through a conference is chronologically.

- There needs to be a way to hold both private conservations and one-way conversations. Sometimes it may not be appropriate to post responses for general consumption. If a specific post is intended for a specific subgroup from a conference or to a specific individual, there must be a way to alert that person (through a pop-up or a different subject field) that the information is private.

- Users need to be able to form a conference on the fly. A conference organizer needs to be able to invite other participates to the conference. As it currently stands, conference participants have to be known ahead of time and subscribe to a conference beforehand; however, staffing is not always the same for every incident. Users need to have a way to request a response from another user or the check that they received a notice of action.

- The weather information needs to be constantly on screen. Users need to be able to see the weather information at the same time as the conference discussion. Weather alerts need to pop-up on the screen.

4.3 Agency Interviews

At the conclusion of the evaluation period, the evaluation team conducted interview with the agency personnel who "subscribed" to the tool. Two subscribers came from IDOT and one subscriber came from the Iowa DOT. Subscribers were asked to provide their perceptions of the usefulness, timeliness, and accuracy of the information provided by the tool. Users were also asked to comment on how agency practices, procedures, and responses to weather events *could* be changed, potentially, because of using the MSCST. The results of agency interviews are summarized below.

4.3.1 General Impressions about MSCST

One subscriber from each agency was asked to provide general perceptions of 1) the overall concept of the MSCST tool (irrespective of the current deployment of that concept), and 2) the readiness of the tool as they experienced it in this demonstration. On a scale of 0 to 10 (with 0 being the "worst" and 10 being the "best"), users were asked to assess the overall concept of the tool along the following dimensions:

- The perceived need for a tool to assist with coordination of weather-related traffic management strategies across jurisdictional boundaries.

- The adaptability of the concept of a tool to assist with multi-state coordination with their current processes, protocols, and procedures.

- The anticipated acceptance of a tool within and between agencies that they routinely dealt with during weather situations.

- The potential for a tool, similar in concept to the demonstrated tool, to improve operations and coordination in their area.

- The potential for a tool, similar in concept to the demonstrated tool, to improve safety during weather events in their area.

- The likelihood the benefits of developing a tool similar in concept to the one demonstrated would outweigh the costs associated with building and deploying that tool in their organization.

Figure 12 shows how agencies rated the MSCST tool along these dimensions. Overall, the users' ratings of the overall concept of a MSCST tool were mixed. One user thought that the concept was not really needed in their organization and provided little benefit. Another user thought that the overall concept of the tool to assist with multi-state strategy selection and coordination would be valuable to their organization and would definitely improve safety and operations in their state.

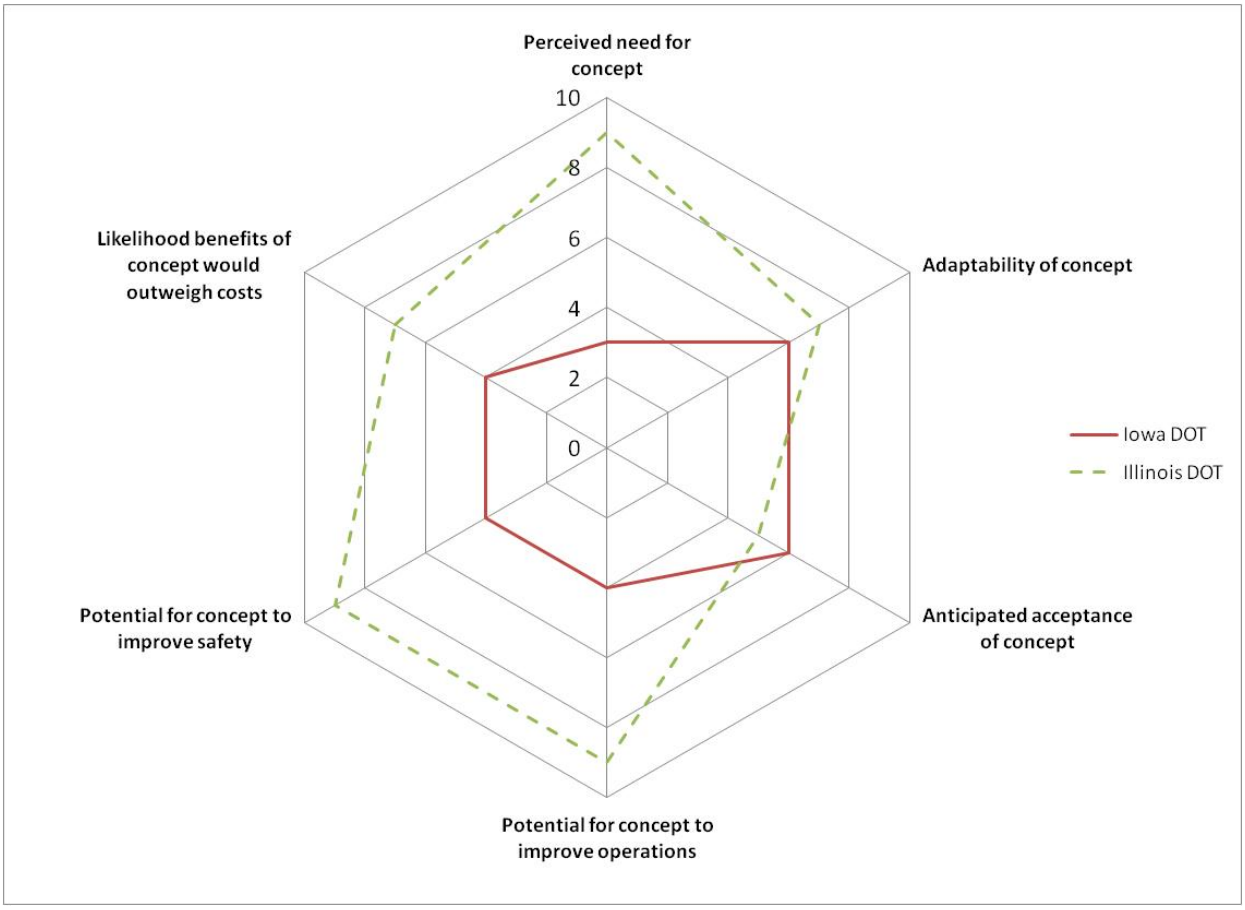


Figure 12. User perceptions of the overall concepts underlying the MSCST

Agencies were also asked to rate the perception of the readiness of the tool, in its current form, for wide-scale deployment. The users were asked to rate the tool's readiness along the following dimensions:

- Ease of set-up and configuring the tool for use.
- Ease of operating and interacting with the tool and navigating through the tool's various weather information screens and conferences.

- The “fit” of the tool with other tools currently used to assist in coordinating weather responses between groups and agencies with which they routinely interact during weather events.
- The perceived level of user trust in the tool and its performance and outputs.
- The perceived reliability and accuracy of the tool and the information it provided.

Figure 13 shows how the agencies rated the readiness of the tool for wide-scale deployment. One agency felt that the tool had significant deficiencies in terms of the level of trust and its accuracy. This agency did not really see how the tool “fit” with their current process, procedures, and protocols for managing traffic operations and coordinating multi-agency responses to weather events. The other agency felt that the tool was much more ready for wide-scale deployment compared to the first user. This agency felt the current deployment of the MSCST was accurate and reliable, but questioned whether users would “trust” the performance and output of the tool.

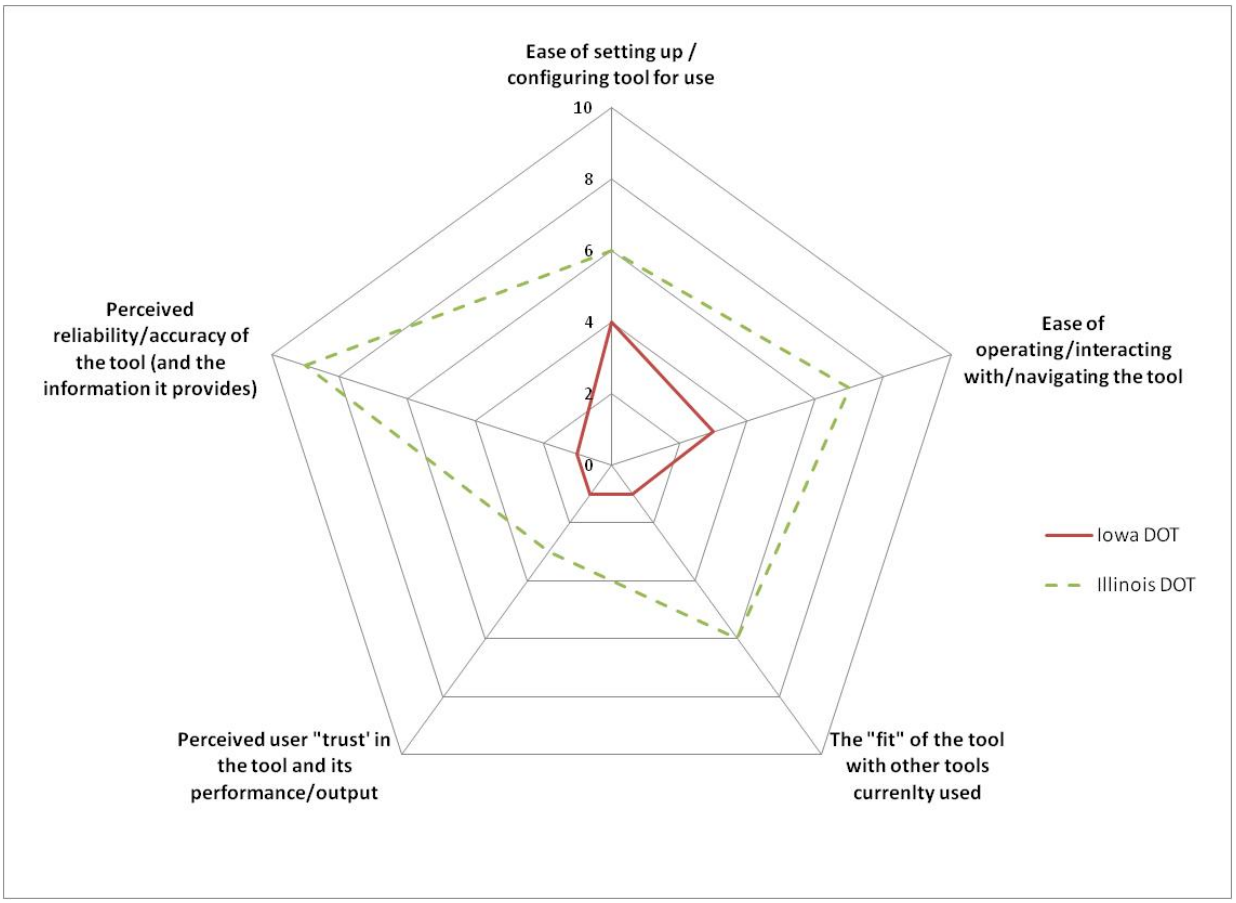


Figure 13. User Perceptions of the Overall Readiness of the MSCST for Wide-scale Deployment

Furthermore, at least one agency felt that, in its current form, the manner in which weather information was presented in the tool needed significant improvement. In its current configuration, the tool provided raw

indications of current weather observations. This made it difficult for novice users and users not familiar with weather data to interpret. Novice users and individuals not familiar with working with weather data need processed weather information—not just raw data. To be more useful, the tool needs to be revised to provide a more effective weather dashboard. At a minimum, the tool needs to be able to support the graphical display of weather information through charts, diagrams, and maps. Ideally, the tool should also support animation of weather data so that users can better visualize the impacts and extent of the weather conditions, both temporally and spatially.

4.3.2 Weather Alerts

During the interviews, both agencies were asked a series of questions relating to the timeliness and accuracy of both the current and forecasted weather information. Both Iowa DOT and IDOT felt that, with one exception, the weather information on which the alerts were based was accurate and timely. Their observations were that the alerts generally coincided with their observations of weather conditions. In particular, IDOT commented that the precipitation alert they used was "right on."

The exception had to do with the frost alerts. Generally, agencies found that the system had a tendency to issue too many frost alerts. Every time a frost alert was issued, each agency received multiple alerts—one alert for every degree below 34° F. This means that every time a frost alert was triggered, an agency received sometimes 5 or 6 alerts per event. After discussing the situation with the system developer, it was learned that the MSCST did not permit the evaluation criteria to be nested. Instead, the tool could only evaluate the criteria in a linear fashion. For example, if the temperature was 30° F, the operator would receive 4 different alerts – one indicating the air temperature was below 34° F, another indicating the air temperature was below 33° F, another indicating the air temperatures was 32° F, and a final alert that the air temperature was 31° F. This caused the agency operators to become inundated with weather alerts—so much so that one agency had to discontinue receiving alerts part way through the evaluation period. This logic flaw would need to be corrected before the tool would be ready for widespread deployment.

The tool also had the capability to provide alerts based on forecasted weather conditions; however, neither agency set up the tool to provide operators with alerts based on forecasted information.

4.3.3 Improvement to Communications between Agencies

Agencies were also asked a series of questions designed to gauge the effectiveness of the tool to improve communication and share information between agencies. This section summarizes the perspective offered by the agency users.

Both state DOTs stated that their current method of communicating internally within their own agency and externally with other agencies was through voice communications—either via the telephone or through a shared radio network. Both agencies indicated that it is often easier and quicker for them to talk with counterparts in other agencies than to communicate through a system like MSCST. Both agencies rated their current level of communications during weather events to be good, and both agencies indicated that they already have well established processes, procedures, and protocols for communicating during major events. Iowa DOT specifically stated that in major storms, most of their communications and coordination occurs through their emergency operations center and that some areas (such as the Quad Cities area) already have strong localized communication networks where the local partners have developed their own communication protocols (calling trees, email lists, etc.) that serve the same function as the MSCST.

During major statewide events, Iowa DOT participates in regularly scheduled conference calls with other agencies and has found this to be a particularly effective means of maintaining coordination during these events. Their emergency management office also has a software tool (called webEOC) that all agencies use to keep track of what actions and tasks have been assigned to each group or agency. They have also used web conferencing techniques to facilitate communication between agencies when there has been a need to share maps and graphics; however, this technique was somewhat problematic since not everyone was at a location where a computer could be easily accessed.

The consensus between the agencies is that the tool would most likely be beneficial to a subset of users in their organizations, if it was easier to use. Those most likely to benefit would be individuals who are located in a control center or dispatch center that needed to coordinate responses of field personnel and with other agencies, and that could access the system through a computer terminal. Both agencies agreed that in its current form, the tool would not be very useful to field personnel because of their limited computer access, and, although attempts were made to permit field personnel to receive alerts via their cellular phones, the process of retrieving and extracting information was too cumbersome to be useful to field personnel.

4.3.4 Data Sharing

One of the purposes of the MSCST was to facilitate data-sharing between agencies; unfortunately, neither of the evaluation agencies used the tool for that purpose. As stated above, both agencies already have well-established processes, procedures, and protocols for sharing data.

Both agencies used the tool primarily as a way to track activities and know who was responding to each situation. IDOT did however use the tool to issue alerts to remind operators to remove messages posted on their DMSs.

To improve the tool's usefulness, both agencies agreed that the tool needs to have the ability to have a public and private way of sharing information—similar to Facebook's method of sharing data. Agencies want to be able not only to post information in a public view that can be shared with everyone who is a subscriber to a conference (which the tool currently does), but also to share data privately with specific users (such as in a private chat window).

4.3.5 Consensus-Building and Decision-Making

Agencies were also asked to comment on how the tool helped with consensus-building and agency decision-making when trying to determine appropriate weather-related traffic management responses across jurisdictional boundaries. Unfortunately, neither of the agencies used the tool for these specific purposes.

Agencies were then asked how the tool could be improved so that it could be used to improve decision-making between agencies. Suggestions for improving the design of the tool to better support decision-making were as follows:

- Revise the tool so that it could support user-defined forecasting (from minutes to multiple days in advance as selected by a user).

- Significantly improve the interface to support graphics, charts, and animation (for showing how a weather event will develop and dissipate over time) and provide all the information that you need via a single interface.

- Provide a graphical representation of the state of the response to an event, so that an operator could tell quickly who had been contacted and what responses had been deployed in response to an event.

- Provide a mechanism in the tool to allow the user to search through the history associated with an event to assist an operator going back through the records to determine what actions were performed by different agencies.

4.3.6 Additional Comments

Agencies were also asked to provide additional information and comments related to the usefulness and practicality of the tool. Below is a summary of these comments.

- There are existing tools that do many of the things that this tool does and do them better (e.g., more sophisticated methods for triggering alerts, better presentation of weather information, etc.). In addition, there is a real need to have a tool that assists with tracking resources during weather-events, particularly those that last several days. While generally the lines of communication between participants are good at the beginning of an event, they deteriorate over time as people get tired, go off duty, etc. Sometimes it is not clear who their replacement is and who you need to talk to when a key contact is not available. The tool should be revised so that a user knows the current contact person for each agency.

- The tool could be improved to provide a mechanism for tracking resources (who is on and off duty, who the current contact is, and what their contact number is, etc.). Everyone has to agree to use the tool and agencies need to have established and agreed upon protocols as to how to use it, when to use it, what information needs to be included, etc. Agencies need to be able to check the status of resources (particularly personnel) quickly, and determine who did what and who said what last.

- During emergency events, a lot of information changes hands quickly. Responders do not like to be over-burdened by emails, and during many parts of an emergency, most responders do not have access to websites or emails. The telephone is the primary tool of choice during emergencies.

- There needs to be a way to mark or set milestones so that you could see the status of an event easier. Also, there needs to be a mechanism that allows the user to see the current status of a situation at quick glance (e.g., police on scene, sheriff notified, etc.). From there, a user could go into conference to get more information if needed (e.g., when did police arrive on scene?).

- In its current configuration, the tool would be useful to log actions taken for a particular event.

5 Lessons Learned and Conclusions

This section highlights some of the lessons learned and conclusions generated based on the information obtained during this evaluation.

5.1 Lessons Learned

Based on the comments received during the tabletop exercise and the post-deployment interviews, the following are some of the lessons learned through this evaluation of the MSCST:

Care must be taken that operators do not become overloaded with information. Depending upon the geographical dimensions of an alert area, this can easily happen, and when it occurs, operators are less likely to find value in an information sharing tool.

User perceptions about the benefits and needs for tools such as the MSCST are highly dependent on the agency's current level of technology sophistication, knowledge about weather, and access to other weather information and tools. Agencies that have extensive experience trying to manage operations during weather events have a much more refined need for and use of weather information and demand more sophisticated tools.

During significant or intense weather events, the workload placed on traffic managers and response operators can be high and conditions can change rapidly. Field personnel are often too busy trying to manage and perform their primary functions during an event to utilize a tool that is not easy to navigate, does not provide accurate and credible information, or is not viewed as being beneficial to their overall work effort. Tools need to be designed to be easily integrated into their current processes and procedures.

The method and manner in which weather information is presented is crucial to users. Traffic managers and operators need information that is not only accurate and timely, but also easy to understand and digest. The use of graphics and animation are critical to presenting weather information.

Users want more than just access to weather data—they want weather information that has been processed and interpreted. Traffic managers and operators want to know when and for how long weather conditions are going to impact operations. Weather information needs to be site specific and tied to features or sections of roadway – not just broad areas.

To achieve widespread acceptance, the tool needs to be a "killer application." The tool must be designed to satisfy a gap in the perceived needs of an agency.

5.2 Conclusions

Based on the findings of the usage statistics, agency interviews and tabletop exercise, the overall conclusion of this evaluation is that while agencies generally agreed that 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. These suggested modifications include the following:

- Improving the tool to make it easier to use and navigate between screens and multiple conferences. The tool must also be improved to make it easier for agencies to add new users, develop new conferences and establish new strategies and alerts.
- Developing a single interface that shows observed and forecast weather conditions, alerts, and agency responses all in a single window, instead of spread over multiple windows.
- Revising the tool to allow support of graphical representation of responses as well as supporting animations of forecasted weather conditions to allow agencies to better visualize impending weather events in the future.
- Providing processed weather information (such as maps and forecasts for impacts) instead of raw observations directly from weather monitoring stations.
- Allowing users to define the type and timeframe for obtaining weather forecast information.

Furthermore, the tool, as currently envisioned, is best suited for dispatch and control center personnel, and not field personnel. Emergency responders indicated that during incident events, they do not have the time to check weather conditions once they are managing an incident condition. Rather, field emergency responders would prefer to be alerted by dispatchers and operators of the time when significant weather changes are likely to occur.

References

American Association of State Highway and Transportation Officials, Institute of Transportation Engineers, and National Electrical Manufacturers Association. 2008. *National transportation communications for ITS protocol: Object definitions for environmental sensor stations (v02)*. Washington, DC: American Association of State Highway and Transportation Officials.

Appendix A

Hazardous Material Spill Tabletop Exercise

Scenario Description and Focus Group Discussion Protocol

Study Objectives:

The purpose of this study is to examine the following two hypotheses:

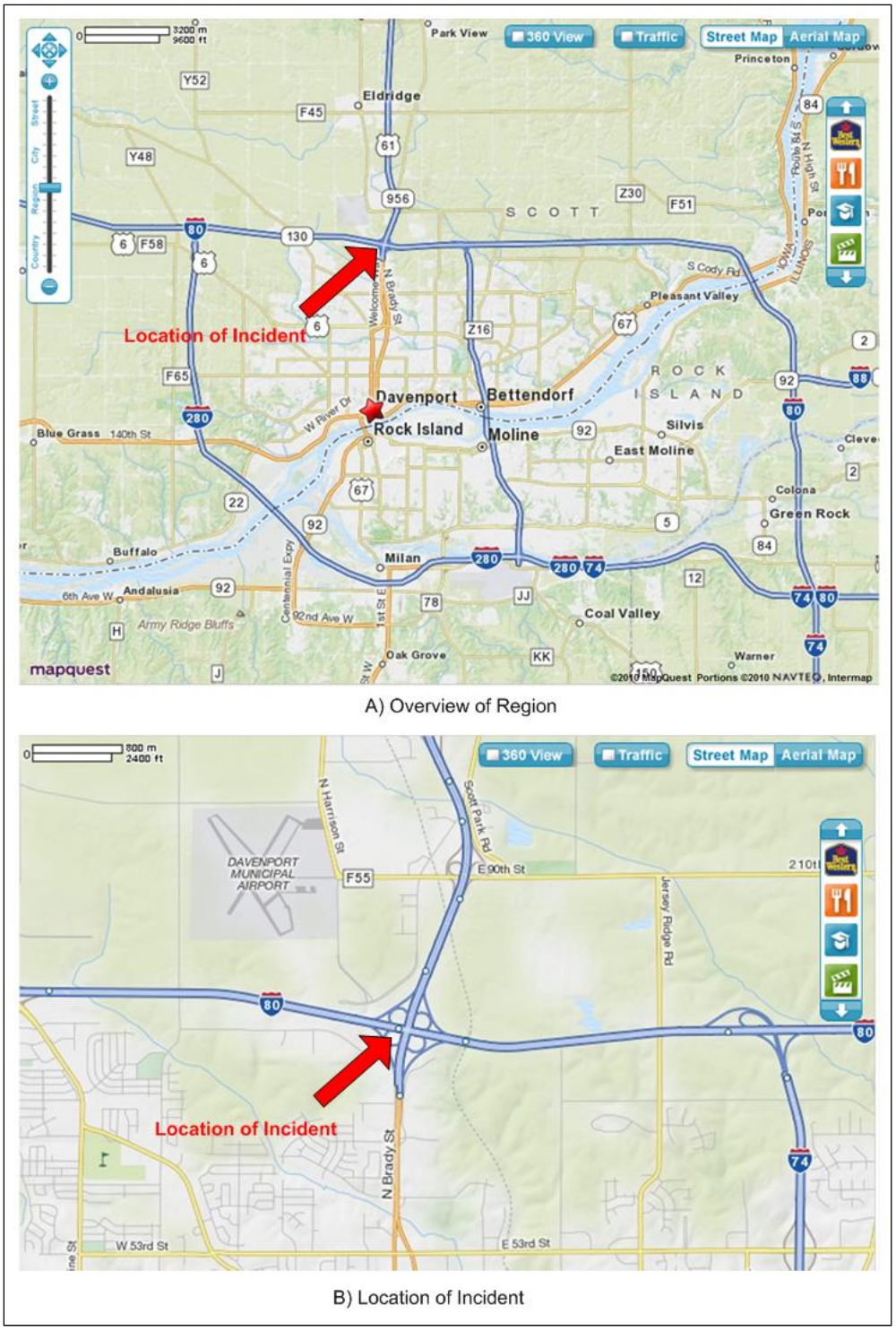
- The MSCST will improve the efficiencies with which responses and weather data and information flow between agencies during an event.
- The MSCST will improve the decision-making process of all agencies involved in responding to an event impacted by weather.

To gain insight into how the MSCST potentially could make these improvements, the evaluation team plans to use a tabletop exercise with transportation and emergency response agencies from the Quad Cities area represented in a MSCST conference. A scenario will be used to test the tool and a facilitated discussion among participants in the conference will be used to evaluate the effectiveness and usefulness of the tool. The scenario will be based on an over-turned tanker truck leaking a hazardous cargo. The location of the hypothetical incident is shown in Figure B1. Participants will be given information about the incident and evolving weather conditions using the MSCST. At the conclusion of the hypothetical event, the evaluation team will facilitate a focus group discussion among participants on the usefulness and benefit of the MSCST in developing traffic management responses to the scenario. This appendix describes the protocol that will be followed in conducting the exercise.

Potential Study Participants:

The potential study participants in the conference for the tabletop exercise will be identified by the two state DOTs and may include representation from the following agencies:

- Iowa Highway Patrol
- Iowa DOT
  - District 6 Traffic Operations
  - Office of Maintenance
  - Statewide Emergency Operations Team
- IDOT
- Illinois Highway Patrol



Source: MapQuest.com

Figure A-1. Location of Hypothetical Over-Turned Tanker Truck in Quad Cities Area

- City of Davenport, Iowa
  - Public Works Department
  - Fire Department
  - Police Department
- City of Rock Island, Illinois
  - Public Works Department
  - Fire Department
  - Police Department
- City of Bettendorf, Iowa
  - Public Works Department
  - Fire Department.
  - Police Department
- City of Moline, Illinois.
  - Public Works Department
  - Fire Department
  - Police Department
- Others identified by Iowa DOT and IDOT

Scenario Description and Facilitated Focus Group Discussion:

The evaluation team will convene a focus group of the conference participants. The purpose of the focus group is to obtain perception information from a group of potential users that can provide insight into how useful the MSCST might be in a real-world event. The facilitator, a member of the Battelle evaluation team, will begin the focus group by performing the following:

- Welcome participants and make introductions
- Describe the purpose of the MSCST and the purpose of the study
- Provide instruction on using the tool (if needed by the participants)
- Describe the study approach and layout the ground rules
- Describe the format for the post-scenario discussion

Participants will be gathered in a large conference room and grouped according to their agency (state DOT, city, etc.) or by their typical duty station during an event of this caliber (i.e., on-scene, in the traffic management center, in office, etc.).Each participant will be given access to the MSCST through a laptop computer or mobile

Smartphone application (a Blackberry). Prior to beginning the scenario, participants will be given instruction on how to use the tool and how to set up strategies for monitoring specific conditions. The group will collectively define strategies with the conference that will be used in the initial assessment of conditions. As the scenario unfolds, study participants will be given periodic alerts and information about the hypothetical incident through the MSCST. Information about weather and roadway surface conditions will be interspersed with the incident information. As participants receive new information, they will be asked to develop traffic advisory and control responses based on the information provided and based upon the actions of other participants. Participants will be asked not to discuss their decision verbally, but instead use the tool to enter their actions based upon the information provided. If additional information is needed from other agencies, participants are asked to use the tool. The facilitator will also use the tool to control the scenarios and provide additional information not otherwise available to the participants.

The following represents is the sequence of events that will comprise the scenario:

9:30 AM: The ambient air temperature is 45° F. Currently the winds are blowing from the Southwest at wind 10 mph. The skies are overcast and it has been raining off and on all night so the pavement surface is wet; however, it is currently not raining at this time. The forecast is for a minor winter storm to blow into the region around 11:30 AM. The weather storm is first expected to bring ice to the area followed by snow. Minor accumulations of snow are expected; however, plowing of the roadways is expected.

9:42 AM: A slight rain begins to fall over the entire region.

9:53AM: 911 receives a call that a tanker truck has just overturned in the I-80/US 61 interchange. There is a report that there is a fluid leaking from the tanker, but it is not clear whether the fluid is coming from the tanker itself or from the fuel tanks on the cab. The caller says that there appears to be fluid leaking from the tanker and there is the weird smell in the air. The tanker is also on fire. The whereabouts and condition of the driver are also unknown. The wreck is reported to be located in the southbound to eastbound portion of the cloverleaf

10:02 AM: Local police and fire arrive on the scene and find that the cab of the truck is on fire. They also find that the impact of the collision has caused a puncture in the first section of the tank. They are able to determine that the tanker is hauling a load of aqueous ammonia, a toxic substance used in agricultural fertilizer that can cause serious burns to the eyes, skin, and lungs. The driver has sustained significant injuries, but has been thrown clear of the cab. Hazardous material crews have been notified and are en-route to incident scene. On-scene responders estimate that it will take at least 4 hours to off-load the tanker.

10:15 AM: Local fire department has extinguished the truck fire.

10:23 AM: Still raining, but intensity has not increased.

10:47 AM HazMat teams arrive on scene. Because of the toxicity of the cargo, the on-scene commander recommends evacuation in place within a 2-mile radius around scene. On-scene commander also worried about hazardous material mixing with roadway runoff and begins implementing strategies to contain roadway runoff. The incident commander also requests new truck to offload remaining ammonia.

11:15 AM	Cold front arrives. Winds shift from southwest to northwest. Sustained winds measured to 25 mph with gusts near 35 mph. Precipitation shifts from rain to sleet. Sleet begins to accumulate on roadway surface. Ambient air temperature begins to fall.
11:20 AM	A new tanker arrives on-scene to begin off-loading disabled tanker contents. The off-loading process is expected to take about 2 hours to complete.
12:02 PM	Approximately a ½ inch of accumulation of sleet reported on roadway surfaces near the incident scene.
12:07 PM	Sleet changes to snowfall. Snowfall rate is moderately heavy. Ambient air temperature is 30°F.
1:40 PM	Off-loading of wrecked tanker is complete. Incident commander issue all clear order and rescinds evacuation-in-place order. Clean-up crews shift attention to clear contaminated soil from around scene. On-scene commander requests assistance in removing contaminated soil.
2:05 PM	Crews arrive on scene to begin process of removing contaminated soil. Crew leader estimates 90 minutes to complete removal of contaminated soil.
2:14 PM	Snowfall continues at moderate rate. Wind speed still at 25 mph sustained. Ambient air temperature nears 20°F.
3:15 PM	Soil removal crew leader reports that contaminated soil has been removed from scene. Removal of wreckage and debris can begin.
3:45 PM	Snowfall begins to abate. Accumulations of around 2 inches have been reported on some roadway surfaces in the vicinity of the incident.
4:04 PM	Wreckage and debris have been removed from the lanes. Maintenance personnel determine that there has been no structural damage from to the roadway surface.
4:45 PM	Incident commander gives okay for all remaining response personnel to leave scene. Remaining emergency responders depart scene. Roadway opened for travel.

Post-Scenario Focus Group Discussion:

At the conclusion of the exercise, we would like to discuss with you your opinions about the utility and benefits of using the tool. The evaluation team plans to make an audio-recording of the discussion; however, audio-recording will serve only to reference for preparing the evaluation report. Once the evaluation report has been prepared and approved by FHWA, the audio-recording will be destroyed.

To begin the post-scenario discussion, we would first ask the participants if they agree to the audio recording. We will stress that all discussions are confidential and no individuals will be identified in reporting of results. We would also instruct participants that we want everyone to have a chance to speak and are looking for honest opinions, both pro and con. After verbal consistent from all participants, we would begin the discussion. Initial

discussion questions are listed below; however, the topics below will not necessarily be covered in order and other topics could be introduced to maintain the flow of ideas.

The following are the questions that will be asked during the facilitated focus group discussion:

Questions Pertaining to This Particular Event:

- If this was an actual event, how would you find out about it? What type of information do you traditionally need to manage this type of event? What are you normal sources of getting that information? How would you normally share response information with others?
- Do the information needs change depending upon where you are located and what your role is in the responding to the incident?
- For this type of event, how does the weather factor into your decision-making process? Did you find having access to the weather information useful to you when you were making decisions about what type of traffic management and advisory strategies to implement? If so how? If not, why not?
- For this particular event, what are your thoughts about the tool? Did you find it useful in this exercise? If so, how? If not, why not? What did you like about the tool? What didn't you like about the tool
- How do you think the tool would function if this was a real event? What are its advantages? What are its disadvantages?
- Compared to your current method for responding to incidents, do you think having the tool improved your level of cooperation and coordination with the other participants? Why/Why not? How?
- For this event do you think having access to the tool improved your efficiency in making decisions? Why?/Why not?

Questions Pertaining to Other Events:

- If the event scenario was different, do you think your responses (in terms of level of coordination, efficiency in decision-making, etc.) would be the same or different compared with this scenario?
- For what types of events do you think the MSCST would be most useful or beneficial?
- For what types of events do you think the MSCST would not be useful or beneficial?
- What are some of the factors that you think need to be considered that would make using the tool beneficial?
- What groups/agencies/organizations do you think would benefit from having the tool?
- What types of improvements/other features would you like to see incorporated into the tool?

Conclusion:

After it is clear that the discussion has run its course, all the participants will be given one last opportunity to express any additional thoughts, concerns, and issues or to ask questions. We will instruct the participants that we will be taking their responses and preparing a summary of the discussion – stating again that responses are confidential and no participant will be identified by name or agency. Participants will be thanked for their participation and then dismissed to return to their normal job duties.

Appendix B

Protocol for Conducting MSCST Agency Interviews

The purpose of this interview is the gauge your perceptions about how the MSCST would improve the degree of cooperation and coordination that exist between you and other agencies you deal with in identifying and deploying traffic management responses during severe weather events. Your responses will be confidential and remain in control of the Battelle Evaluation Team. Please feel free to elaborate on any of your responses. Thank you for your participation.

General Impressions about the MSCST

How would you rate the level of communication between agencies you deal with during severe weather events?

☐ 1 – Poor ☐ 2 – Marginal ☐ 3 – Average ☐ 4 –- Good ☐ 5 – Outstanding

In which of the following conferences did you participate?

☐ 1 – Weather Alerts ☐ 2 – Marginal ☐ 3 – Other

On average, how many weather-alert conference did you participate in each month?

☐ 1 – Less than 2 ☐ 2 – 3 to 5 ☐ 3 – 6 to 10 ☐ 4 –- 11 to 20 ☐ 5 – Greater than 20 ☐ 6 – NA

Did you add or create your own weather-alert strategy(ies) in the MSCST?

☐ 1 – Yes ☐ 2 – No ☐ 3 – Don't Know

If so, what were they and what did they do?

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On a scale of "1" to "5", with "1" being poor and "5" being outstanding, how would you rate the ability to establish new strategies?

☐ 1 – Poor ☐ 2 – Marginal ☐ 3 – Average ☐ 4 –- Good ☐ 5 – Outstanding ☐ 6 – NA

Weather Alerts

Did you find the information about current weather conditions to be accurate?

☐ 1 – Yes ☐ 2 – No ☐ 3 – Undecided

Did you find the information about current weather conditions to be timely?

☐ 1 – Yes ☐ 2 – No ☐ 3 – Undecided

Did you find the information about forecasted weather conditions to be accurate?

☐ 1 – Yes ☐ 2 – No ☐ 3 – Undecided

Did you find the information about forecasted weather conditions to be timely?

☐ 1 – Yes ☐ 2 – No ☐ 3 – Undecided

Did you find the information about forecasted weather conditions to be useful?

☐ 1 – Yes ☐ 2 – No ☐ 3 – Undecided

Can you describe your typical experience using one of the conferences as an example?

- Were you the initiator of the conference or a participant (subscriber)?
- What was the conference about? What were the strategies associated with this conference?
- Did you add any strategies to the conference? If so, what were they?
- What kind of traffic management advisory and control strategies did you recommend or implement in response to the situation?

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Improve Communication between Agencies

What mechanisms do you currently use to communication and share information between agencies?

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How would you rate the current level of communication between agencies you make traffic management and control decisions with during weather events?

☐ 1 – Poor ☐ 2 – Marginal ☐ 3 – Average ☐ 4 –- Good ☐ 5 – Outstanding

Compared to your current method of sharing weather and traffic management information during events (i.e., without the MSCST), do you think the level of communication between agencies during weather events would be likely to improve if the MSCST was widely deployed in your region?

☐ 1 –Yes ☐ 2 –No ☐ 3 – Don't know

Why/Why Not?

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In your use of the MSCST, can you describe for me a situation in which you participated where the MSCST improved communication between responding agencies?

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In your use of the MSCST, can you describe for me a situation in which you participated where the MSCST DID NOT improve communication between responding agencies?

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How would you rate the frequency of communication between agencies you deal with during severe weather events?

☐ 1 – Poor ☐ 2 – Marginal ☐ 3 – Average ☐ 4 –- Good ☐ 5 – Outstanding

Compared to your current method of sharing weather and traffic management information during events (i.e., without the MSCST), do you think the frequency of communication between agencies during weather events would be likely to improve if the MSCST was widely deployed in your region?

☐ 1 –Yes ☐ 2 –No ☐ 3 – Don't know

Why/Why Not?

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How would you rate the quality of communication between agencies you deal with during severe weather events?

☐ 1 – Poor ☐ 2 – Marginal ☐ 3 – Average ☐ 4 –- Good ☐ 5 – Outstanding

Compared to your current method of sharing weather and traffic management information during events (i.e., without the MSCST), do you think the quality of communication and coordination between agencies during weather events would be likely to improve if the MSCST was widely deployed in your region?

☐ 1 –Yes ☐ 2 –No ☐ 3 – Don't know

Why/Why Not?

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Do you think having access to the MSCT help you overcome any existing institutional, procedural, and/or technical barriers that might have previously limited your ability to coordinate with other agencies?

☐ 1 –Yes ☐ 2 –No ☐ 3 – Don't know

If yes, how? (please describe)

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Data Sharing

How would you rate the level of data sharing about traffic management control strategies between agencies you deal with during severe weather events?

☐ 1 – Poor ☐ 2 – Marginal ☐ 3 – Average ☐ 4 –- Good ☐ 5 – Outstanding

How would you rate the level of data sharing about traffic management advisory strategies between agencies you deal with during severe weather events?

☐ 1 – Poor ☐ 2 – Marginal ☐ 3 – Average ☐ 4 –- Good ☐ 5 – Outstanding

How would you rate the level of data sharing about roadway/surface treatment strategies between agencies you deal with during severe weather events?

☐ 1 – Poor ☐ 2 – Marginal ☐ 3 – Average ☐ 4 –- Good ☐ 5 – Outstanding

How would you rate the level of willingness to share data and information between agencies you deal with during severe weather events?

☐ 1 – Poor ☐ 2 – Marginal ☐ 3 – Average ☐ 4 –- Good ☐ 5 – Outstanding

Consensus-Building/Decision-Making

How would you rate the decision-making between agencies you deal with during severe weather events?

☐ 1 – Poor ☐ 2 – Marginal ☐ 3 – Average ☐ 4 –- Good ☐ 5 – Outstanding

How would you rate the ease at which consensus is reached between agencies as to what traffic management control, advisory, and treatment strategies to deploy during severe weather events?

☐ 1 – Poor ☐ 2 – Marginal ☐ 3 – Average ☐ 4 –- Good ☐ 5 – Outstanding

How would you rate the degree of support between agencies when decisions are made during severe weather events?

☐ 1 – Poor ☐ 2 – Marginal ☐ 3 – Average ☐ 4 –- Good ☐ 5 – Outstanding

Do you feel that having access to the MSCST changed how your agency responds to weather events?

☐ 1 – Yes ☐ 2 – No

If yes, how?

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Did having access to the tool improve your decision-making capabilities?

☐ 1 – Yes ☐ 2 – No

If yes, how?

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Did you consult the tool before you implemented new or modified existing control or advisory traffic management strategies?

☐ 1 – Yes ☐ 2 – No

If so, how often?

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Did you ever change your mind about implementing a particular control or advisory traffic management strategy after consulting the MSCST?

☐ 1 – Yes ☐ 2 – No

Why/Why not?

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Do you think having access to the MSCST helped you proactively manage traffic in certain situations?

☐ 1 – Yes ☐ 2 – No

If so, can you describe a situation in which that occurred?

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Do you think having access to the MSCST helped reduce congestion in a particular weather situation?

☐ 1 – Yes ☐ 2 – No

If so, can you describe a situation in which that occurred?

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Do you think having access to the MSCST, if fully deployed, has the potential to reduce congestion during weather events?

☐ 1 – Yes ☐ 2 – No

If yes, how? / If no, why not?

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Do you think having access to the MSCST helped improved safety in a particular weather situation?

☐ 1 – Yes ☐ 2 – No

If so, can you describe a situation in which that occurred?

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Do you think having access to the MSCST, if fully deployed, has the potential to improve safety during weather events?

☐ 1 – Yes ☐ 2 – No

If yes, how? / If no, why not?

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Additional Feedback

Please share any additional comments.

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Thank you for participating in this interview. Again, your responses will be help confidential. If you have any questions or have additional feedback, please feel free to contact me at 979-845-9899.

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