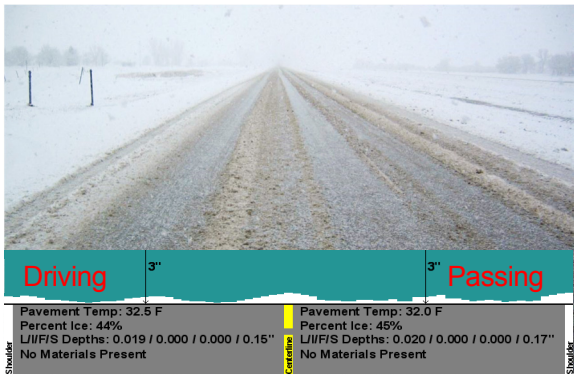
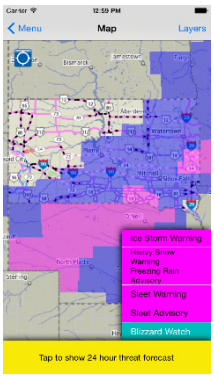
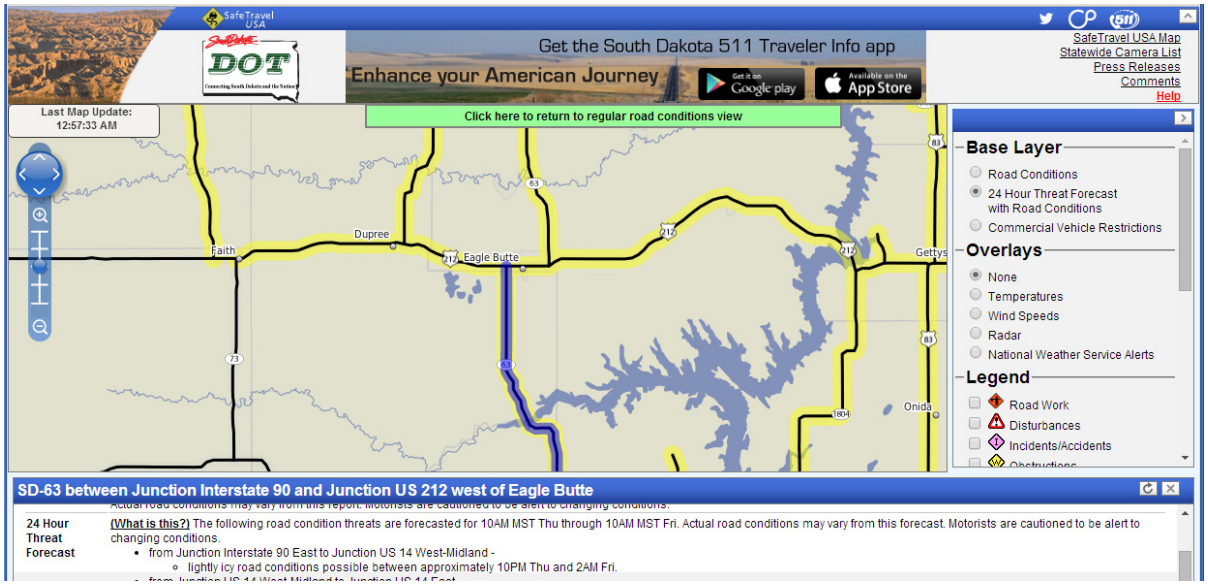
FHWA-JPO-16-269

South Dakota Department of Transportation (SDDOT) Regional Traveler Information System for Weather Responsive Traffic Management

Final Report – November 2015







www.its.dot.gov/index.htm

U.S. Department of Transportation
Federal Highway Administration

Produced by Federal Highway Administration Road Weather Management Program for
ITS Joint Program Office
U.S. Department of Transportation

Cover photos from South Dakota Department of Transportation

Notice

Technical Report Documentation Page

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
FHWA-JPO-16-269		

4. Title and Subtitle	5. Report Date
South Dakota Department of Transportation (SDDOT) Regional Traveler Information System for Weather Responsive Traffic Management	November 2015
	6. Performing Organization Code

7. Author(s)	8. Performing Organization Report No.
Fred Kitchener (McFarland Management, LLC), Dave Huft (South Dakota DOT), Greg Ostermeier (Iteris, Inc.), Murat Omay, Chris Toth, and Michael Waisley (Battelle)	

9. Performing Organization Name and Address	10. Work Unit No. (TRAIS)
Battelle, 505 King Avenue, Columbus, OH 43201 McFarland Management, LLC, 1015 W. Hays Street, Boise, ID 83702	11. Contract or Grant No.

12. Sponsoring Agency Name and Address	13. Type of Report and Period Covered
U.S. Department of Transportation Federal Highway Administration Office of Operations 1200 New Jersey Avenue, SE Washington, DC 20590	Final Report (Oct. 2013 - Oct. 2015)
	14. Sponsoring Agency Code

15. Supplementary Notes

FHWA Project Manager – Roemer Alfelor, FHWA South Dakota Division Liaison – Bruce Hunt

16. Abstract

Federal Highway Administration's (FHWA) Road Weather Management Program (RWMP) strives to promote the development and implementation of cutting-edge techniques for maintaining safety, mobility, and productivity of roadways during adverse weather conditions. The FHWA RWMP partnered with the South Dakota DOT to develop and implement a Weather Responsive Traffic Management (WRTM) strategy that involves mobile data collection and traveler information dissemination during weather events. A concept of operations and an evaluation plan were developed and utilized in the project. The objectives of the system were to improve the efficiency of road condition data collection, increase the number and frequency of road condition reports, improve and expand road weather information provided to travelers, enhance the perceived benefits to travelers from the new traveler information, and support partner agencies that can use the new traveler information. This report documents the development, implementation and evaluation of the system. Overall, the evaluations indicate that travelers value road condition forecasts. Furthermore, after viewing road condition forecasts, the travelers' either changed the timing or routing of their trips, or felt more prepared for them. The report also contains lessons learned and recommendations based on the evaluation results.

17. Key Words	18. Distribution Statement
Road Weather Management, Weather Responsive Traffic Management, Road Condition Forecasts, Mobile Data Collectors	

19. Security Classif.(of this report)	20. Security Classif.(of this page)	21. No. of Pages	22. Price
Unclassified	Unclassified	70	

Form DOT F 1700.7 (8-72) Reproduction of completed page authorized

Acknowledgements

The members of the consultant team would like to acknowledge and thank Dave Huft (South Dakota DOT) for leading the successful implementation and evaluation of the Regional Traveler Information System for Weather Responsive Traffic Management project. Additionally, the team would like to extend their gratitude to the South Dakota DOT Maintenance and Operations personnel who were instrumental to the project implementation and evaluation. Finally, the team thanks Roemer Alfelor (FHWA) for his ongoing support and technical guidance of this study.

Table of Contents

List of Tables

List of Figures

Executive Summary

Weather Responsive Traffic Management (WRTM) involves implementation of traffic advisory, control, and treatment strategies in direct response to anticipated or occurring roadway and visibility issues that result from forecasted or deteriorating weather conditions. WRTM also includes providing proactive advisories and control strategies based on forecasted weather conditions, and not just the impacts of those conditions. One of the primary focus areas of the Federal Highway Administration's (FHWA) Road Weather Management Program (RWMP) has been to encourage the development and implementation of WRTM strategies. Specifically, this report describes the system development and implementation, and summarizes the evaluation of the South Dakota DOT (SDDOT) Regional Traveler Information System for WRTM.

Initial Implementation of the South Dakota DOT WRTM Project

The objectives of the South Dakota Regional Traveler Information System for WRTM Project were to:

1. Improve the efficiency of road condition data collection by SDDOT maintenance staff
2. Increase the number and frequency of road condition reports
3. Improve and expand the road weather information provided to travelers
4. Increase the perceived benefits to travelers from the expanded/improved traveler information
5. Support partner agencies through their use of the expanded/improved traveler information

The project implementation was divided into two distinct and important elements to improve both the road weather data collection and the content and amount of traveler information being provided to motorists in South Dakota. The project goals were to:

1. Simplify the collection of traveler information source data by allowing plow drivers to directly populate the Integrated Roadway Information System (IRIS) with road weather conditions via a newly developed software application accessible on the plow truck Mobile Data Collectors (MDCs)
2. Provide new traveler information to motorists to include 24-hour road condition threat forecasts, and expansion of the number and type of National Weather Service (NWS) alerts.

The first project element developed a special software application that allowed plow drivers to enter road conditions into the IRIS system directly using their MDCs that already existed in the trucks. This was an improvement over the current process because it provided them immediate and direct access to IRIS instead of using the radio to inform a supervisor who would enter the road conditions into IRIS at their desk or the maintenance staff would enter it in the office at the end of a run or shift.

Unfortunately, the application was not completed in time for implementation during the winter season. However, maintenance personnel tested the application in a plow truck during simulated scenarios and were able to express their opinions about how it might benefit them during the next winter.

The second project element focused on providing motorists new road condition information on the SafeTravelUSA website, 511 phone system, and mobile phone applications. The 24-hour road condition forecasts came directly from the South Dakota DOT Maintenance Decision Support System (MDSS) and were represented to the public through their traveler information systems as possible future "threats" when road conditions might be deteriorating into an unsafe situation. The new information also included expansion in the type and number of National Weather System (NWS) alerts and related information.

Evaluation Findings

The initial implementation of the South Dakota Regional Traveler Information System for WRTM was evaluated to assess its effectiveness and potential to improve both South Dakota's road condition reporting and information provided through the traveler information system. The evaluation focused on five hypotheses associated with this objective. Table ES-1 shows the five hypotheses and the summary of the primary results for each. Note that Hypothesis 2 was not completed as planned and; therefore, no results are shown in the table.

Table ES-1. SDDOT WRTM Project Evaluation Hypotheses and Summary of Results

Hypothesis	Summary of Results

1: The project will improve efficiency of road condition data collection by SDDOT maintenance forces.	• A survey of maintenance personnel during the early testing of the IRIS application indicated that:
	  ○ 78% would use the application to report road conditions when conditions change
	  ○ 74% would be able to enter road condition reports more efficiently
	  ○ 83% would be able to describe road conditions more accurately
	  ○ 91% would be able to report road conditions sooner after making the observation
	  ○ 78% would be able to enter road condition reports more frequently
	• Maintenance personnel said the future benefits would be:
	  ○ Keeping the public informed; quicker
	  ○ Assist the public with travel decisions
	  ○ More road reporting; faster; more often
	  ○ More accurate reports; better descriptions
	  ○ Easier to post condition reports
	  ○ Less time in the office posting reports

2: The project will increase the number and frequency of road condition reports.	Not completed
3: The project will improve and expand road weather information provided to travelers.	• Nearly 100,000 24-hour road condition threat forecasts were issued • Over 42,000 hours of National Weather Service alerts were issued • 300,000 website views were made where 24-hour road condition threat forecasts were available

Table ES-1. SDDOT WRTM Project Evaluation Hypotheses and Summary of Results (Continued)

Hypothesis	Summary of Results

4: Travelers on South Dakota roads will perceive benefits from the expanded/improved traveler information.	• Based on an Internet survey, the following percentages of SDDOT traveler information users viewed or listened to 24-hour road condition threat forecasts:
	  ○ 67% website users
	  ○ 49% mobile phone users
	  ○ 36% 511 phone callers
	• The majority of users said information was easy to find and understand
	• Between 80-87% of respondents found information to be “quite” useful or “very” useful
	• Respondents said their travel plans were affected, where:
	  ○ 60% changed the timing of their travel
	  ○ 53% changed the routing of their travel
	  ○ 76% felt more prepared for their upcoming travel

5: Partner agencies in SD will benefit from the expanded/improved traveler information.	• A specific evaluation of partner agencies benefit from new traveler information was not possible, however the following benefits are expected in the future:
	  ○ Agencies whose employees travel extensively could adjust travel schedules and routes to avoid periods involving 24-hour road condition threats.
	  ○ Agencies that deliver travel-related services could prepare and schedule for increased demand during periods of road condition threats.
	  ○ In instances of severe weather events, advance knowledge of the road condition threats could help organizations decide whether to cancel conferences, athletic contests, or other events requiring travel.

Source: Battelle/McFarland Management

Conclusions

The enhanced and expanded information provided to travelers through the SDDOT websites, mobile phone apps, and 511 phone system can be used by motorists to make prudent and safe travel decisions and improve their overall travel experience in South Dakota. Specifically, the 24-hour road condition threat forecasts can be used to help motorists of all types better plan their travel and be prepared for the potential road conditions. Additionally, the use of the South Dakota DOT in-vehicle IRIS application is expected to improve the effectiveness and efficiency of road condition reporting during weather events. This upgraded road condition reporting will in-turn improve the timeliness and accuracy of the traveler information.

SDDOT is planning to continue providing the 24-hour road condition threat forecasts and NWS alerts, with possible enhancements to the information display. They are also planning to deploy the IRIS application in plow vehicles to improve upon the road condition reporting throughout South Dakota. SDDOT will continue monitoring and evaluating these new features in the coming year to improve the collection and dissemination of essential traveler information.

Chapter 1 – Introduction

Weather Responsive Traffic Management (WRTM) involves implementation of traffic advisory, control, and treatment strategies in direct response to anticipated or occurring roadway and visibility issues that result from forecasted or deteriorating weather conditions. WRTM also includes providing proactive advisories and control strategies based on forecasted weather conditions, and not just the impacts of those conditions. One of the primary focus areas of the Federal Highway Administration's (FHWA) Road Weather Management Program (RWMP) has been to encourage the development and implementation of WRTM strategies.

In 2011, the RWMP initiated a project to document existing strategies for WRTM, identify improvements to the strategies, and develop implementable Concepts of Operations for the improved strategies.[1]

This report describes the development, implementation and evaluation of one of those strategies for improving regional traveler information during weather events in South Dakota.

1.1 Project Overview

The project addresses improvements in road weather data collection as well as the content and amount of traveler information provided to motorists in South Dakota. Thus, the primary goals were to 1) simplify the collection of road condition data by allowing plow drivers to directly populate the Integrated Roadway Information System (IRIS) via a newly developed software application accessible on the plow truck Mobile Data Computers (MDCs), and 2) provide new traveler information to motorists including 24-hour forecasts of road conditions, and expanded NWS alerts. The road condition forecasts came directly from MDSS and be classified as possible future "threats" when conditions might be deteriorating into an unsafe situation.

The SDDOT WRTM project is specifically intended to:

- Improve the efficiency of road condition data collection by SDDOT maintenance staff
- Increase the number and frequency of road condition reports
- Improve and expand the road weather information provided to travelers
- Increase the travelers' perceived benefits of the improved/expanded traveler information

[1] FHWA, Developments in Weather Responsive Traffic Management Strategies, June 2011, FHWA-JPO-11-086, available at http://ntl.bts.gov/lib/42000/42900/42965/wrtm_final_report_06302011.pdf

1.2 Organization of the Report

The rest of the report describes the SDDOT traveler information system in detail including the implementation, operations, and evaluations conducted as part of this effort. The report is organized as follows:

- Chapter 2 describes the SDDOT road condition reporting system
- Chapter 3 describes the system development and implementation
- Chapter 4 describes the evaluation approach
- Chapter 5 provides the results of the evaluation
- Chapter 6 summarizes the conclusions and lessons learned
- Chapter 7 provides system recommendations
- Appendix A includes the list of abbreviations and acronyms
- Appendix B includes the complete evaluation plan for this implementation.

Chapter 2 – System Description

2.1 Existing SDDOT Systems

For several years SDDOT has utilized a Maintenance Decision Support System (MDSS), based on a platform provided by Iteris®, to assist with managing road maintenance operations as well as an Advanced Traveler Information System (ATIS) to provide travelers information about roadway status and events.

The MDSS product integrates recent and current weather data, roadway reports, and other data from snow plows indicating their maintenance activities on the roads, along with forecasts from weather and pavement models. These data are compiled to build a representation of current and projected roadway conditions. Based on preferences and targets set by the state, MDSS can provide recommendations for maintenance activities to optimize resource use in achieving levels of service for roadways.

The South Dakota ATIS system utilizes information from a database of road conditions and events affecting the roadways through a reporting software called the Integrated Roadway Information System (IRIS). The information is input to the database by the state personnel. That information populates the IRIS database and generates content for the traveling public about the status of the statewide road network. The content is disseminated through the telephone-based 511 system, the SafeTravelUSA website, the mobile applications (apps) for iOS and Android alerting services that provide emails and text messages for certain types of situations, and several other mechanisms.

Users obtain information from The South Dakota ATIS mainly by accessing the website or apps to view an illustrated road status or to select segment reports for predefined road sections, which also can be accessed by dialing the 511 system. Maps are useful for a quick view of the general picture of road conditions. The segment reports allow description of all details for a chosen road section and are the only means of information for non-visual media such as the 511 system.

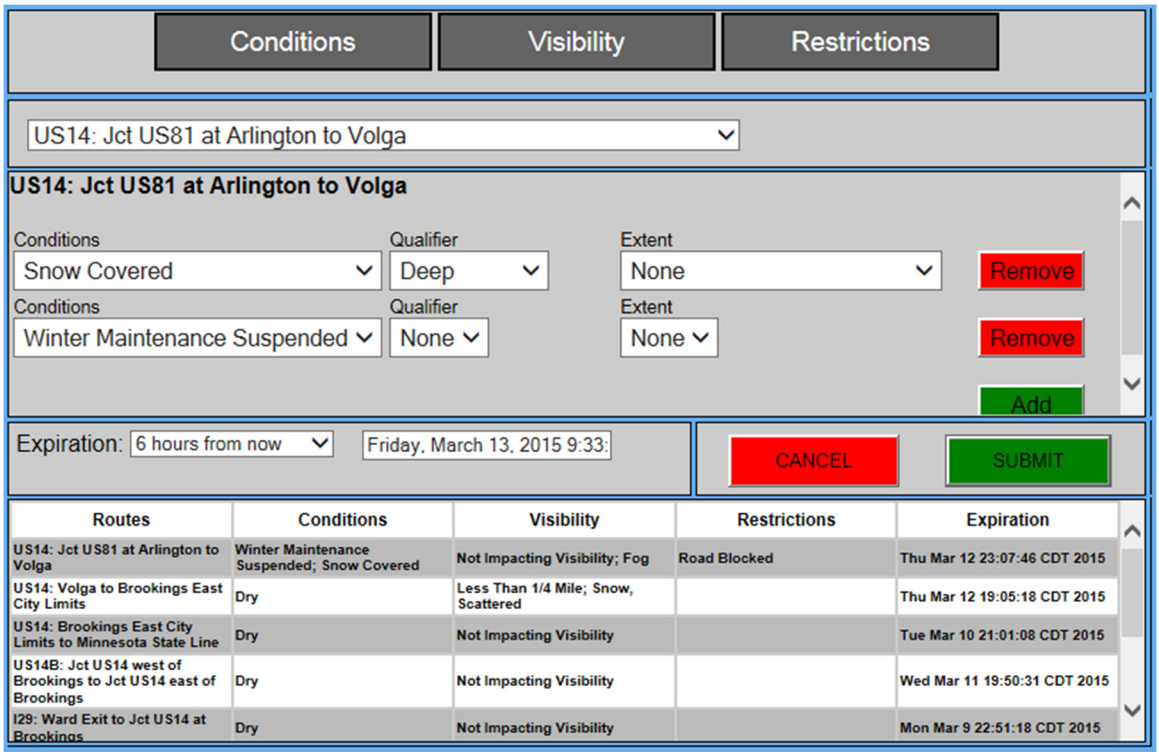
SDDOT recognized that there could be value using real-time input to the MDSS from snow plow operators to enhance (or supplement) the road condition information, analysis, and forecast information in ATIS. This implementation provides the integration of ATIS and MDSS, where the information component of ATIS is also enhanced by several other additions that facilitate the operator-to-IRIS and IRIS-to-ATIS reporting process.

2.2 IRIS Application on MDCs

To facilitate the ability for snow plow operators to report road condition information directly into IRIS, and subsequently into the greater ATIS system, an in-truck IRIS application was developed. The advantage of this approach is that the snow plow operators no longer have to communicate the information to a separate IRIS operator, thus allowing the condition reporting to be more complete, timely, and efficient.

The application developed for this purpose was a simpler version of the full website that mimicked the road conditions reporting interface of IRIS, which could be run from the touchscreen computers in the snow plows. Trucks could access this new interface and report on the nearby road maintenance reporting segments associated with the truck's home shop. This new tool was similar in principle to the menu interface through which drivers have been able to report road and weather conditions, in addition to other information that is ultimately captured and used by MDSS.

Figure 2-1 shows a screen capture of the IRIS application. Initially, the application loads the Conditions screen. Buttons across the top provide access to that screen plus the Visibility and Restrictions screens where more information can be set. The first step is to update the screen by selecting the road segment from the pulldown menu. There are typically 6 to 12 segment choices available, depending on the shop the truck is associated with.



Source: SDDOT

Figure 2-1. IRIS Application Screen

Conditions Screen – When a segment is selected, the last reported conditions for that segment are shown on the Conditions Screen. Any previously set conditions can be removed, and any new or updated conditions can be added. Up to four different conditions may be defined for a segment. There are three possible components to an entry, which are all included in the pulldown menus. The conditions are required fields to be input by selecting the appropriate descriptions from the pulldown menu (e.g., “frost,” “black ice,” “packed snow,” etc.). Qualifiers (e.g., “scattered” or “mostly”) and extents (e.g., “passing lane” or “on bridges”) are optional inputs to provide more specification.

Visibility Screen – The Visibility Screen works similar to the Conditions Screen and allows for entering a description for the degree of reduced visibility. Particular obstructions (e.g., “blowing snow” or “fog”) can be defined, each with a specific qualifier and/or extent.

Restrictions Screen – The Restrictions Screen offers additional advisory conditions (e.g., "No Travel Advised" or "Reduced Speed") that may be reported for the selected segment by selecting the relevant checkboxes. In the initial deployment, the “Road Blocked” and “Road Impassable” options were deactivated in the application to disallow the closure of road segments through this tool. This feature can be re-activated in future deployments.

At any point when the selections are made in the Conditions, Visibility, and Restrictions tabs, the expiration time may be set from a pulldown menu. The options include choices of times specified as numbers of hours after the current time.

The final step is pushing the completed report to the database. The “Submit” button becomes only functional when adequate and valid information is entered in the appropriate fields of the screens. Selecting that button pushes the completed report for the segment to the IRIS database. If at any point an operator wishes to abandon changes for a segment or start over the editing process, the “Cancel” button works as a refresh button to clear updates and reinitialize with the previously reported state.

A table below the input sections on the screen shows the latest reported conditions for the segments within the coverage area specific to a truck. This is solely informational and can allow a driver to see that given segments may already have been appropriately coded to show up-to-date conditions, thus do not require updating.

The application is web-based and is accessible virtually from anywhere. Anyone who has access to a truck’s login information can access the application and input conditions enter information regarding the as if they were in that truck. The remote accessibility feature of this web-based application provides a first step in making IRIS widely available to users who do not need to be at a workstation or access the application from a computer that is part of the state computer network with the proper software and access.

2.3 Road Condition Threat Forecasts

2.3.1 Approach and Source of Road Condition Forecast Threats

A prominent capability of MDSS is to provide information about localized impacts on roadways. The system’s most significant ATIS user information addition is the road condition threat forecasts. This additional threat forecast uses MDSS analysis of current road conditions to predict road conditions for the next 24 hours.

After being configured with the entire road network on which the ATIS reports, MDSS continuously produces road condition forecast data for all the road segments. MDSS incorporates a combination of weather and pavement modeling and generates output for its defined road segments describing predicted weather, road conditions, and blowing snow. Table 2-1 identifies the forecast road condition phrasing mapped to the MDSS output condition. For each hour of the forecast period a worst-case status can be selected for each of these descriptions—e.g. type and intensity of precipitation, type and degree of road conditions, and severity of blowing snow. The MDSS distills and summarizes the data for the benefit and ease of ATIS users.

The threat forecasts supplement the latest reported conditions to provide travelers more information. In some cases, such as overnight periods, road conditions reports may not have been updated as frequently. In such cases, the current threat forecast may help provide a better picture of existing road

conditions when compared with the last reported update. Also, current road conditions can change quickly, making recent reports inapplicable.

Table 2-1. Forecast Condition Phrasing Mapped to MDSS Conditions

	Forecast Condition Phrases					
	lightly icy conditions	**icy conditions**	**lightly snowy conditions**	**snowy conditions**	**lightly slushy conditions**	**slushy conditions**
MDSS Road Condition	Damp Near Freezing	Frost Likely	Dusting of Snow	Snow-covered	Lightly Slushy	Slushy
	Wet Near Freezing	Icy	Lightly Snow-covered	Deep Snow		Deep Slush
	Some Risk of Frost	Very Icy		Compacted Snow		
	Chemically Wet					
	Lightly Icy					
MDSS Weather Condition	Moderate Sleet		Moderate Snow	Blowing Snow		
	Heavy Sleet		Heavy Snow			
	Freezing Drizzle		Moderate Rain/Snow Mix			
	Freezing Light Rain		Heavy Rain/Snow Mix			
	Moderate Freezing Rain					
	Heavy Freezing Rain					

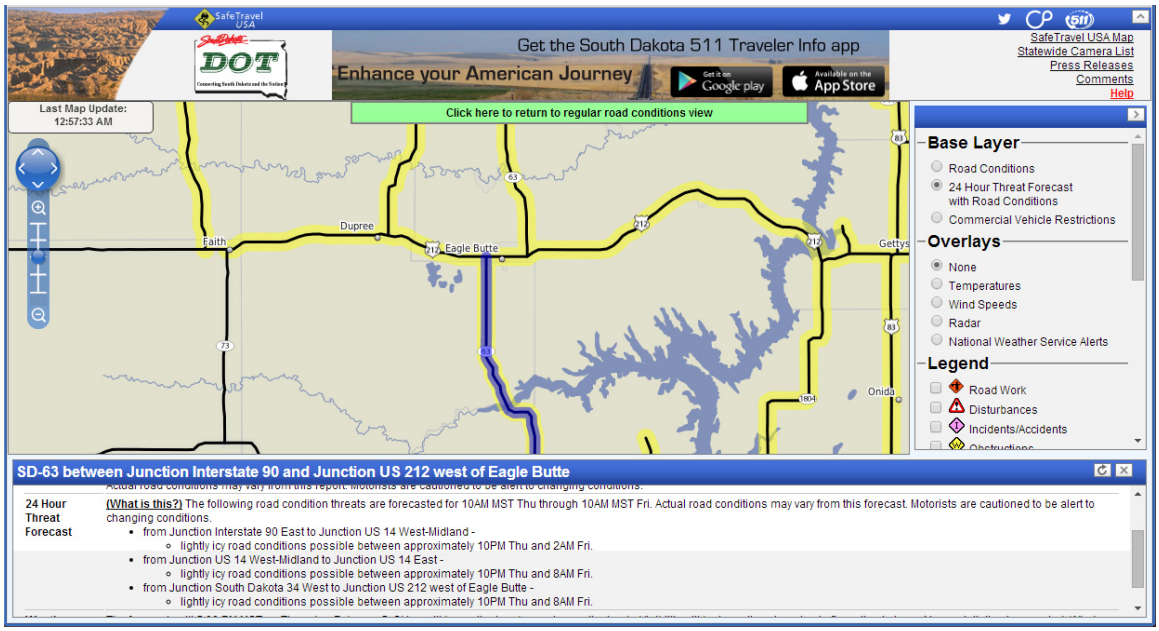
Source: SDDOT

These forecasts do not incorporate consideration of possible maintenance activities. Maintenance could very much affect the status of the roads and thus how accurate the forecasts may actually be, but the benefit of the forecasts is not their precision but rather as a signal of noteworthy conditions that may affect travelers. The system design is based on the assumption that even if maintenance were applied the "threat" condition would occur at least temporarily during the forecast period.

2.3.2 Additional Information provided to Travelers

The threat forecasts are conveyed visually (maps) on the website and smartphone apps, and textually within the segment reports, including on the 511 phone system. The maps show a quick indication of where threat forecasts exist any time during the next 24 hours. This is done with yellow highlighting around the roads, which remain otherwise colored according to the situations last reported. A newly added section of the segment reports provides more detail about the expected nature and timing of

the hazardous conditions. Figure 2-2 illustrates an example of the yellow road highlighting indicating a threat forecast is present and the description of the threat at the bottom of the map. Where there is no applicable threat forecast, the road will not have the yellow highlighting, and there will be no reference to a threat forecast in the segment report. It is important to note that threat forecasts are not shown for closed roads in order to avoid misrepresenting that the roadway will be open when the actual information regarding the closure or re-opening is not known with certainty, the forecasts are not shown for those road sections.



Source: SDDOT

Figure 2-2. Yellow Highlights Indicating a Road Condition Forecast on the SafeTravelUSA Website

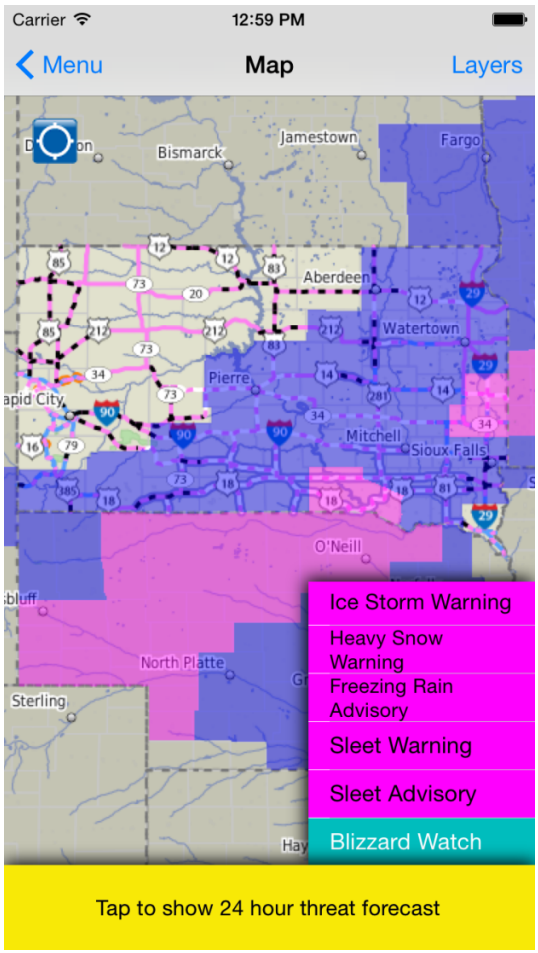
Whichever tool a user chooses to view a segment report (e.g., 511, website, or apps),the threat forecast for that segment will be provided to include any road segment that is selected from the view and that is not currently showing the threat forecast highlight.

2.4 National Weather Service Products

When the National Weather Service's Watch, Warning, Advisory (WWA) product information was first incorporated in the ATIS a few years ago, the 511, website, and app reports for a selected road segment contained a note regarding certain active NWS products. However, the extent of the information had been very limited. Only warnings for the most severe situations (Blizzard, Ice Storm, Tornado, Severe Thunderstorm, and Flash Flood) were included, along with the basic details noting the product type and the location of the segment.

The WRTM project expanded the NWS WWA information on the website and apps to increase relevant weather information for travelers. More information has been made available covering a wider range of products that link to full NWS product messages.

An overlay for the ATIS map similar to those for temperature, wind, and radar is now available to show the current spatial coverage of NWS products. The overlay presents dozens of different NWS products. Figure 2-3 illustrates an example of a NWS products overlay. Previous to this project, only six NWS products (all warnings) were available on traveler information systems for tornados, severe thunderstorm, flash flood, blizzard, winter storm, and ice storm. The added NWS products included 54 separate possible conditions encompassing other warnings, watches, advisories, and statements. The road segment reports on the website or app now also cite any NWS products active anywhere on that segment that would appear on the overlay. Such a note includes a link to the official NWS message that provides the full text associated with that issued product.



Source: SDDOT

Figure 2-3. National Weather Service Products Overlay on the SDDOT Mobile App

2.5 Road Weather DMS Messages

SDDOT currently has a network of 30 dynamic messages signs (DMS) along Interstate 29 and Interstate 90 in the state. Certain SDDOT personnel are able to update the message content for the signs. This project's goal was to employ those signs as another dissemination method for road weather related ATIS information. Messages can be generated for each sign to report on the current roadway status for a defined span downstream from each sign.

The initial aim was to make potential messages available to decision makers so they could have the option to post them manually. After the DMS (road weather) content generation, messages providing the new content may be posted onto a website and sent via email to make that information available to personnel who control the signs. Those who can set the DMS could then decide from the provided list what, if anything, to report.

All of the types of current road weather situations that may be reported were prioritized for message generation. Threat forecast information beyond the analysis of current conditions were irrelevant and not included for DMS messages because travelers are assumed to quickly pass through the area adjacent to the sign. The priority level determines which situation to report if there are multiple options at a given time, such as both wintry road conditions and active NWS products.

The DMS content generation is operational, but is not yet being fully provided to SDDOT. When they are receiving and assessing the potential messages, SDDOT will help refine the message prioritization scheme. Messages eventually may be automatically posted to DMS if a mechanism can be established to connect directly to the system, and complete agreement can be reached on what to post when.

2.6 Data Sources

Additions to the ATIS system include new data sources. The following summarizes those changes.

- Road conditions
  - The in-truck reporting tool provides a new mechanism for input to the IRIS database. Otherwise the IRIS system was unchanged. The change is expanded access to a reporting interface.
- Roadway status information through dissemination methods
  - The threat forecasts added to road segment reports represent a completely new type of data in the traveler information system, but it is a variation of data already familiar to SDDOT. A particular instance of MDSS processing was created for the SDDOT road network. The output from the roadway/weather and blowing snow models is fed into the content generation process and creates the maps and reports for the website, apps, and 511.
- NWS products
  - All of the additional NWS data had been available for use but was not previously displayed. The changes include the integration of the map overlay, the expansion of products reported, and links to the actual NWS product messages.

2.7 Operational Process Changes Needed

Most of the changes related to this implementation involve software updates for providing additional information to travelers. The most significant operational change is having SDDOT snow plow operators report road conditions through the in-truck IRIS tool. They are collecting the same information through a new tool that allows easier and more frequent reporting.

Chapter 3 – System Development and Implementation

3.1 Concept of Operations Overview

A technical panel convened at the beginning of the project and met multiple times during the development process to help make decisions on how to proceed with implementation. Some of these meetings took place in person and some via phone or web. This group consisted of about a dozen individuals with a wide range of affiliations and expertise in the various facets of the system, to include weather and forecasting, road maintenance, and intelligent transportation systems. The outcome of this system development process was a Concept of Operations document, which can be found at the following URL: http://sddot.com/business/research/projects/docs/SD2013-12-C_WRTMI_ConOps_Final.pdf.

3.2 IRIS Application

3.2.1 Design and Approach

The initial design concept for the IRIS application would automatically transfer information from in-truck mobile data collectors into IRIS and MDSS. The driver-selected information for road and weather conditions that flow into MDSS would have also been fed into IRIS. However, translating MDC data reports into IRIS terminology and converting the point MDC reports into segment IRIS reports would have produced imprecise results in IRIS. Because of the significant differences between the MDC and IRIS systems this initial approach was abandoned, and the current IRIS application was developed.

It was decided that a simpler website version of the current IRIS interface was preferable because it could be incorporated into the in-truck computer. It would also circumvent translation barriers between the different MDSS and IRIS reporting languages and location schemes. The approach would have only a portion of the functionality (with no maps) and reduced ability to set road conditions. Also, drivers would have to input information into the IRIS application, since this approach would not be fully automated.

The new MDC interface is similar to the current website IRIS interface, which is familiar to many snow plow operators, and typically requires several touchscreen selections to set segment road conditions. The goal was to minimize the effort for information collection and offer ease of use, so the plow operators would be more likely to utilize the tool.

3.2.2 Software Development and Implementation, Testing, Deployment

In developing a website tool for reporting road conditions, a key goal was making it very similar to the current website IRIS client interface. This effort had to occur within the following constraints of the in-truck computers:

- user interaction by drivers can be only assumed through touchscreen,
- screen resolution is a small 800x600 pixels on an area of only about 7x5 inches,
- outdated internet browser (Internet Explorer 7, originally released in 2006).

This simple operating environment required the web tool to be relatively basic, and limited the programming tools and options for creating it.

The website that was set up in maintenance vehicles currently only provides the capability to update road conditions; however, this first step could lead to providing SDDOT access to the full road reporting capabilities in IRIS. This could include reporting on construction, events, and restrictions.

IRIS users were given personnel credentials based on regional groupings. This allows permissions to be set for users limiting what they can edit and where. Credentials for a new “truck” user was established within the IRIS database for each snow plow in the state fleet, and the user was placed in a group associated with the shop where the vehicle is based. Thus each truck was granted access to update the conditions for the road segments maintained by its shop.

Development of this interface occurred on desktop computers, but an in-truck computer for testing was provided to confirm expected behavior. A relatively simple XML file within each truck's computer configured access to several options on the computer, including a set of bookmarked websites to which the IRIS application would be added. SDDOT personnel programmed into each truck MDC computer the URL and the specific parameters that allowed the database to communicate the appropriate segments for the truck. Simply selecting the road conditions reporting website loaded the interface on the truck computer, and the segments for which the truck had access, were available to update.

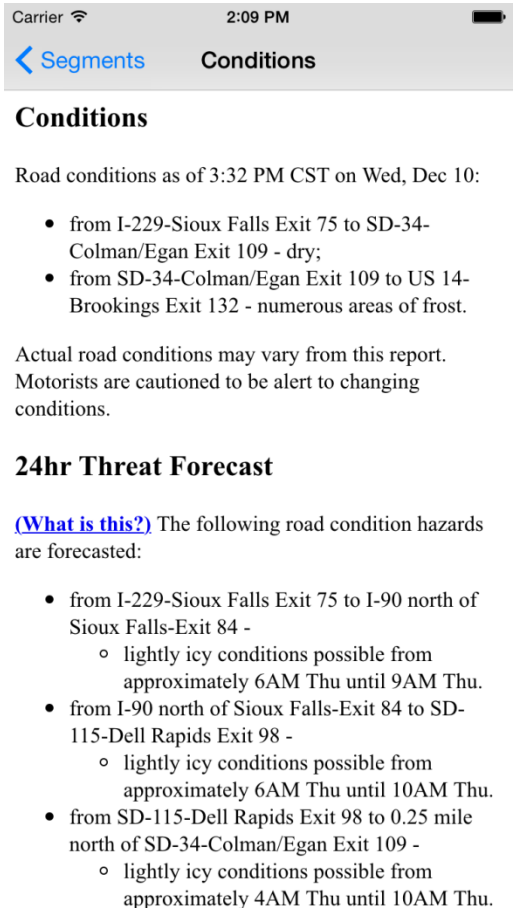
Because the development process extended through the winter, the website was deployed only in testing mode, which implemented a non-production IRIS database to a subset of trucks. This allowed for a subset of drivers to experiment, test, and evaluate the tool using a database that was separate from the operational ATIS. The results of this evaluation will determine how many of the approximately 100 trucks in the state fleet equipped with MDC computers will be set up with the reporting website pointing to the live IRIS database, thus allowing the full intended in-truck conditions reporting.

3.3 New Information on Traveler Information System

3.3.1 Design and Approach

Displaying the new information on the traveler information website and phone systems presented numerous challenges that were addressed by the stakeholder group in several meetings. Initial ideas included more complicated roadway coloring schemes or showing multiple time slices for the threat forecast on the maps. Ultimately ease of use for travelers in accessing and interpreting the forecasted road condition information was a leading consideration that guided many key design decisions.

A single additional map base layer for summarizing the whole forecast period was built. On the website and app maps, roads with a threat forecast occurring for any period within the 24 hours timeframe are given a yellow highlighting. Beyond that simple visual indicator, the segment reports on the website, apps, and 511 provide some details about the forecast. The report for a segment with a threat forecast provides the approximate timeframe when the forecast is applicable and a general description of the most adverse conditions expected. The scheme for the descriptions is simple with "snowy," "icy," and "slushy," along with possible "lightly" modifier when applicable (e.g., "snowy conditions" or "lightly icy conditions)." Figure 3-1 provides an example of text details available for road conditions and 24-hour threat forecasts.



Source: SDDOT

Figure 3-1. Example of Road Condition and 24-Hour Threat Forecast Details

Threat forecasts may have slightly different content for adjacent road segments. To minimize the number of forecast descriptions for each segment and thus making that information more accessible for users, post-processing was added to combine adjacent segments whose threat forecasts are similar. For example, two consecutive road segments with forecasts of lightly icy from 10:00 AM to 4:00 PM and icy conditions from 11:00 AM to 6:00 PM would not be described separately but would be joined and have the whole segment described with icy conditions from 10am to 6pm.

3.3.2 Software Development and Implementation, Testing, Deployment

The threat forecast additions involved parallel efforts to generate the new data and content, and to update the website, apps, and 511 for content distribution. MDSS was configured to cover the statewide ATIS road network with the same segmentation SDDOT uses for reporting conditions and to produce the forecast data for those segments. The threat forecasts were distilled into the brief summary of the conditions over the affected timeframe and into the new base layer, including the yellow road highlighting. Testing occurred as data were pushed to demo versions of the website and apps for evaluation so that additional content could be generated in parallel to the production of the ATIS system.

Though the report content is always accessible, the threat forecast layer was not made to be displayed on the maps by default. On the website, a user must actively select to view the roads base layer including the threat forecast coloring. To encourage users to view the threat forecast layer and make that information easier to access than through the usual website and app map controls, an additional control was placed on the map when threat forecast information was present anywhere in the state. This new control is a small clickable banner with a yellow background and a note that clicking in the banner will switch the base layer to also show the threat forecast information. Similarly, when the threat forecast base layer is active, the banner is made green with a note that clicking it will return the user to the regular road conditions view without the yellow highlighting.

During development it was recognized that very slight differences in conditions and timeframes for threat forecasts on adjacent road spans could generate rather long reports. Often there are about 3-6 different reporting spans per road segment, and each could possibly have its own threat forecast slightly varying from its neighbors. An algorithm was developed for merging threat forecasts of adjacent spans if their conditions and periods are similar enough. Thus a series of spans composing a segment all with threat forecasts of icy conditions but ending variously between 7pm and 10pm that otherwise would each be described individually may be combined into only one threat forecast statement noting icy conditions possible across the whole of the segment through 10pm. This further small sacrifice of forecast precision facilitates greater brevity to keep the details from overwhelming the general message.

The NWS overlay and report additions plus the small addition of weather station data to the camera image viewer for sites with weather station data followed similar though simpler paths. The raw data were organized and processed to be formatted for the website and apps to use, and those dissemination methods were updated to incorporate the additions.

The additional content was made live on 511, the website, and the apps in January 2015. Similar to previous deployments, the updates for the website and 511 were pushed live on a day with relatively benign weather. If there had been a problem during deployment it would not have affected users at a critical time. New versions of the mobile apps that could provide the new information were pushed out, despite a two week delay getting approval for release of the iOS version through the Apple App Store. Use statistics indicated that within several days of availability, app user's versions were overwhelmingly up-to-date.

Chapter 4 – Evaluation Approach

During the project planning phase, a detailed project evaluation plan was prepared. The complete Evaluation Plan is contained in Appendix B. The information below summarizes the evaluation approach.

The project implementation was divided into two distinct and important elements. The first project element developed a special software application that allowed plow drivers to enter road conditions into the IRIS system directly using their MDCs that already existed in the trucks. This was an improvement over the current process because it gave them immediate and direct access to IRIS instead of using the radio to inform a supervisor who would enter the road conditions into IRIS at their desk or the maintenance staff would enter it themselves in the office at the end of a run or shift. The second project element was focused on providing motorists new road condition information on the SafeTravelUSA website, 511 phone system, and mobile phone applications. The 24-hour road condition forecasts came directly from the South Dakota DOT Maintenance Decision Support System (MDSS) and were represented to the public through their traveler information systems as possible future "threats" when road conditions might be deteriorating into an unsafe situation. The new information also included expansion in the type and number of National Weather System (NWS) alerts and related information.

The evaluation plan defined the following five hypotheses to be tested (which included both project elements):

1. The project will improve efficiency of road condition data collection by SDDOT maintenance forces
2. The project will increase the number and frequency of road condition reports
3. The project will improve and expand road weather information provided to travelers
4. Travelers on South Dakota roads will perceive greater benefits from the expanded/ improved traveler information
5. Partner agencies in SD will benefit from the expanded/improved traveler information

Table 4-1 summarizes the project evaluation hypotheses, measures of effectiveness (MOEs), and required data elements. The MOEs and data elements represent an evaluation approach that combined both quantitative and qualitative analyses. Some adjustments were made to the evaluation approach due to unforeseen project challenges which are discussed in the next Chapter.

The quantitative analysis, using system log data, primarily focused on documenting quantities of expanded road weather information and website/mobile phone app hit statistics. The qualitative analysis compiled results from two surveys: an internet survey of travelers who obtained the new traveler information and were willing to share their thoughts, and a survey of select maintenance staff who used the IRIS application on the MDCs in a simulated scenario.

The next chapter describes the evaluation results using the data available during the 2015 South Dakota winter season.

Table 4-1. SDDOT WRTM Project Evaluation Hypotheses, MOEs, and Data Elements

Hypothesis	Measures of Effectiveness	Data Needs
1. The project will improve efficiency of road condition data collection by SDDOT maintenance forces	• Expression of value from SDDOT maintenance staff regarding new processes and the resulting data	• Maintenance staff logged levels of system satisfaction during 2014-2015 winter (several times during the season) • Interviews with maintenance staff
2. The project will increase the number and frequency of road condition reports	• Number and frequency of road and weather condition reports (by segment) made in 2014-15 winter season – compare those equipped with the technology versus those not-equipped with the technology • System usage perceptions by Maintenance staff	• Newly created system logs • Interviews with maintenance staff
3. The project will improve and expand road weather information provided to travelers	• Number of road condition forecast content provided on webpage, 511 phone, and mobile apps • Number of NWS severe weather warnings provided on webpage • Number of road weather and NWS warning messages posted on DMS relative to the total possible number of messages posted	• Newly created system logs • Newly created system logs • Newly created system logs

4. Travelers on South Dakota roads will perceive benefits from the expanded/ improved traveler information	• Expression of value from travelers regarding new information – traveler types include:
	  • General travelers
	  • Non-DOT state employees
	  • Commercial Vehicle Operators (CVOs)
	  • Other volunteers
		• Website and phone hit statistics
		• Internet survey
		• Participant surveys

5. Partner agencies in SD will benefit from the expanded/ improved traveler information	• Input from other SD agencies or neighboring states indicate benefits were realized from WRTM generated information. Possible participants include:
	  • SD Highway Patrol
	  • Emergency Responders
	  • Local law enforcement
		• Interviews with partners

Source: Battelle/McFarland Management

Chapter 5 – Evaluation Results

5.1 Background

South Dakota DOT provides road weather condition information from maintenance vehicles for two primary reasons: 1) to support and direct maintenance winter operations – by feeding key information to their Maintenance Decision Support System (MDSS); and 2) to support their traveler information systems (SafeTravelUSA website, 511 phone system, and mobile smartphone applications) with timely and accurate information. The data management and system operations to achieve these operational objectives, as well as detailed weather forecasting, are supplied to SDDOT through a contract to a private contractor, Iteris®.

Currently road condition information is provided by plow operators via radio and Mobile Data Computers in the vehicles. Information input into the MDCs directly feeds the MDSS, but not the traveler information systems. Traveler information source data are radioed by plow operators to maintenance stations where staff input the information into a data management system called IRIS. IRIS updates the traveler information database that feeds the various dissemination media. The traveler information includes road and weather conditions. Weather forecasts are provided to travelers, but road condition forecasts had not previously been provided to the travelers as part of the traveler information system(s).

The primary objectives of this WRTM project were to:

- Simplify the collection of traveler information source data by allowing plow drivers to directly populate IRIS with road weather conditions via a newly-developed software application accessible through in-vehicle MDCs.
- Provide motorists new information including 24-hour road condition forecasts and expanded NWS warnings. The road condition forecasts derive from MDSS and are represented as “possible future threats” when conditions might deteriorate to an unsafe situation.

Chapters 2 and 3 described the technology and systems that were implemented to achieve these goals.

Due to delays in system development, the evaluation had to be adjusted. The first project element, IRIS application on the MDCs, was not completed until June 2015; therefore, it was not operational during the winter season when the plow trucks were operating. However, members of the SDDOT maintenance staff were able to access the application in a simulated scenario in the plow trucks and report their experiences with the application/tool in a survey. The analyses of Hypotheses 1 and 2 were adjusted to eliminate the quantitative data collection (Hypothesis 2) and rely solely on qualitative results (Hypothesis 1) from the survey responses.

The second project element, new traveler information, was completed and operational by the end of January 2015 and was available to motorists during the latter part of the winter season.

5.2 Data Analysis

The results presented in this section represent quantitative analyses of the collected data and qualitative analyses of the responses to surveys. The collected data focused primarily on numbers of road condition forecast threats by road segment, NWS warnings, and hit statistics for the website/phone app. The source data for the qualitative analyses originated from two surveys: an internet survey of travelers to gain an understanding of their awareness and use of the road condition forecast threats; and a survey of maintenance staff that used the new IRIS application through the interface of in-vehicle MDCs.

This data analysis section is divided into four primary sections corresponding to each of the four hypotheses being evaluated. The sections include the study of improved road condition reporting, expanded information to travelers, travelers' impression of expanded information, and the potential benefits of the information to other partner agencies. The results include the perceptions of maintenance staff after using the new IRIS application on the MDCs, measuring the amount of new information disseminated to travelers through South Dakota's various media, and travelers' expression of value from viewing the new information.

5.3 Improved Road Condition Reporting (Hypothesis 1)

The evaluation of this hypothesis focused on the results of a survey conducted among maintenance staff who had an opportunity to test the IRIS application on the plow truck MDC. Twenty-three maintenance staff from 10 different units had the opportunity to test the IRIS application in a simulated scenario. As previously mentioned, the application was not ready for use during the winter season.

All 23 respondents reported that the application was either easy to use or very easy to use. They reported the most likely benefits of using the MDC IRIS application would be:

- Keeping the public informed; quicker information to the public
- Assist public with travel decisions
- Increased, faster, and more frequent road reporting
- More accurate reports; better descriptions
- Easier to make road condition reports
- Less time in the office posting reports

From these early evaluation results it appears that the IRIS application has great potential. SDDOT plans to deploy the application in many of the plow trucks in the 2015-16 winter season, and complete the evaluation as an internal activity.

Additional survey results are reported below.

5.3.1 When Would the Application Be Used

Maintenance staff were asked "how often do you think you would use the IRIS Application? (please check all that apply)" Possible responses provided in the survey included:

- On each plow route
- When road conditions change significantly
- To meet the 3 times per day reporting requirement
- When a long way from my shop computer
- Rarely or never
- Other

The responses and their distribution are shown in Table 5-1 below.

Table 5-1. How Often IRIS Application Might Be Used

Response	Number Recorded	Percent of Total
On each plow route	5	21.7%
When road conditions change significantly	18	78.3%
To meet the 3 times per day reporting requirement	5	21.7%
When a long way from my shop computer	5	21.7%
Rarely or never	2	8.7%
Other	4	17.4%

Source: SDDOT

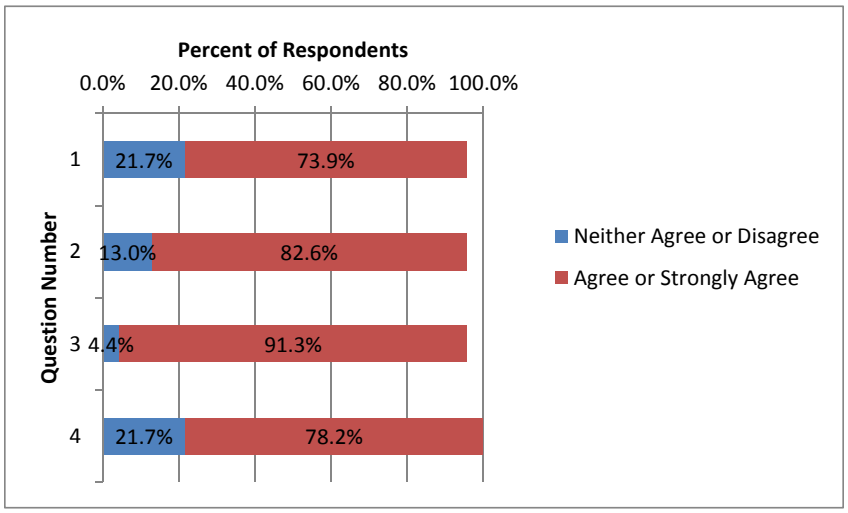
The vast majority responded with "When road condition change significantly," which is aligned with the goal of the department. It appears that the IRIS application will be beneficial in helping to achieve that goal.

5.3.2 Expected Benefits to Maintenance Operations

During the survey, maintenance personnel were asked to indicate their agreement or disagreement with the following statements:

1. I expect to be able to enter road condition reports more efficiently
2. I expect to be able to describe road condition more accurately
3. I expect to be able to report road conditions sooner after making my observations
4. I expect to be able to enter road condition reports more frequently

Figure 5-1 illustrates the distribution of the responses. No one responded with a "Strongly Disagree" answer. For questions 1-3, one individual responded with a "Disagree" answer. The majority of respondents either agreed or strongly agreed with each of the statements. This indicates that when this tool is deployed it will likely benefit both the maintenance staff and the traveling public. The road condition reports made by maintenance staff will likely be made more efficiently, more accurately and closer to the observations, and more frequently. This should translate to more timely and accurate information to travelers. Future evaluation activities will focus on measuring whether these statements are realized when the application is deployed and tested during winter weather conditions.



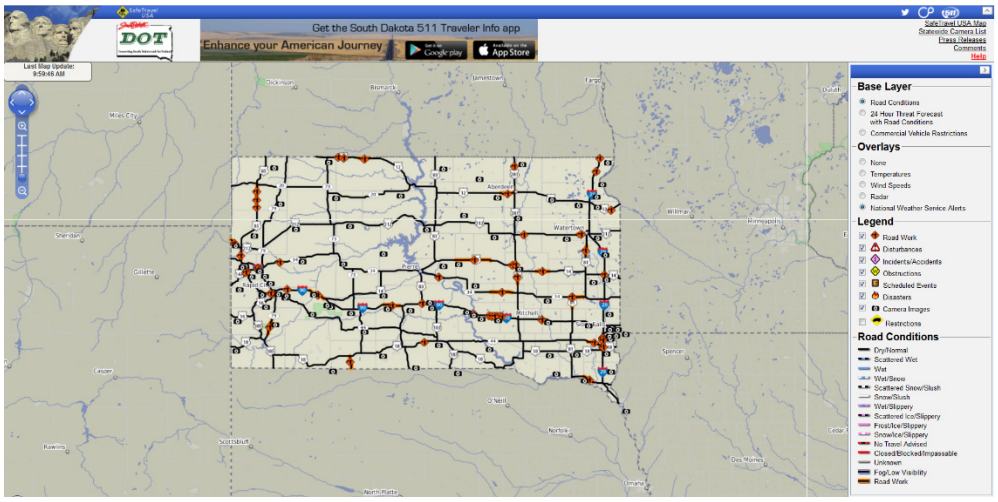
Source: Battelle/McFarland Management, data from SDDOT

Figure 5-1. Survey Responses of IRIS Application Benefits to Maintenance Operations

5.4 Expanded Information to Travelers (Hypothesis 3)

South Dakota disseminates road weather information though the SafeTravelUSA website[2], 511 phone system, and smartphone mobile applications. When navigating to the website, the user is presented with the screen shown in Figure 5-2. As the user moves the cursor across the map, road segments will highlight for selection. When the user clicks on a segment, information about that specific segment is displayed at the bottom of the screen. Types of information include road conditions and a weather forecast, and threat forecast, construction, and restrictions (i.e. width/length/height restrictions), as applicable.

[2] http://www.safetravelusa.com/sd/



Source: SDDOT

Figure 5-2. SafeTravelUSA Website Screenshot

As defined previously, measures of effectiveness for this hypothesis included:

- The number of road condition forecast content provided on the webpage, 511 phone, and mobile applications
- The number of NWS weather warnings provided on webpage, and
- The number of road weather and NWS warning messages posted on DMS relative to the total possible number of messages posted.

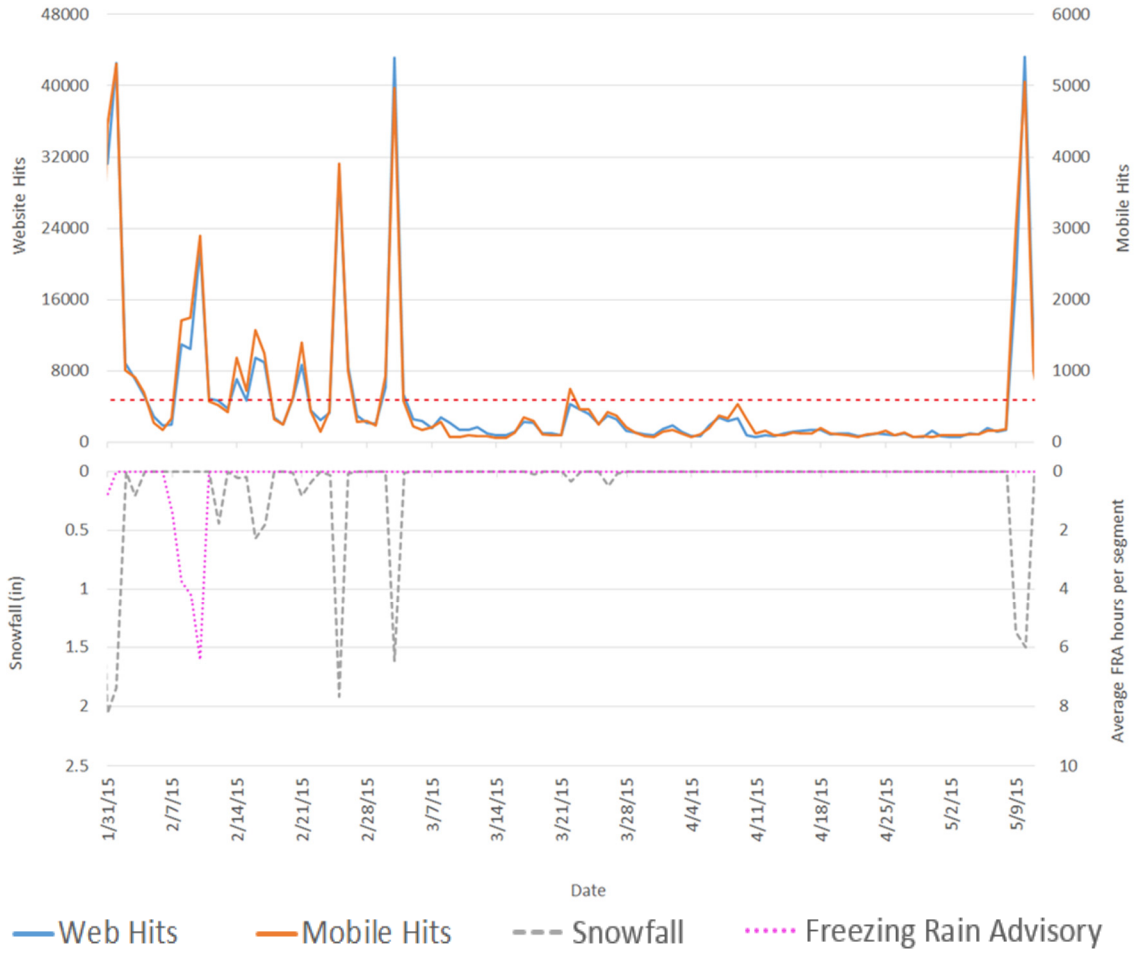
Thus far, data were obtained from the following sources during different periods:

- Website Use Statistics (1/31/15 – 5/12/15, 102 days)
- Threat Forecast Log (1/20/15 – 4/8/15, 79 days)
- NWS Alerts Log (1/31/15 – 5/12/15, 102 days)

Website use statistics, along with a log of threat forecasts and NWS alerts, provided the first two measures of effectiveness. However, DMS message data were not available, so the third measure of effectiveness could not be assessed. Several analyses have been performed for assessing 24-hour road condition threat forecasts, website/mobile application use, and National Weather Service alerts.

5.4.1 Weather Events (Defining Storm and Non-Storm Days)

The presence of storms should be accounted for when analyzing and interpreting the increased quantity of road weather information and website use statistics. One indication of the presence of inclement weather is the number of website hits – the number of times the website was visited over a given timeframe. The time-series diagram in Figure 5-3 shows the daily number of website hits and mobile hits over the entire evaluation period (1/31/15-5/12/15). Also shown is the corresponding time series for snowfall (a population-weighted average for several cities throughout South Dakota) and average freezing rain advisory hours on roadway segments throughout the state.



Source: Battelle, data from SDDOT

Figure 5-3. SafeTravelUSA Website Hits, Snowfall, and Freezing Rain Advisories

The number of website hits in a day appears to fall into two clusters: below 5000 hits and above 5000 hits as shown above by the level dashed red line in the upper graph. These clusters are expected to represent the difference between days with and without storms. The confirmation for use of these criteria is presented in the bottom graph of Figure 5-3. From the graph, the increases in website and mobile use correlate with increased snowfall intensity and the presence of freezing rain advisories. While most of the spikes in use can be attributed to snowfall, there is a period of time from February 7 to February 10 when freezing rain prompted increased website use.

In conclusion, more website visits were noted during periods of inclement weather conditions in the winter months. Based on the observed correlation between the need for information and inclement weather conditions, an opportunity presented itself, which was to provide the website visitors with road condition and weather alert information when it is needed most. The following sections assess the availability of road condition and weather alert information, and how much of this information was accessed by the public.

5.4.2 Road Condition Forecast Threats

Segment-by-segment threat forecasts were generated to indicate whether a weather event was expected to affect roadway surface conditions over the next 24 hours. This forecast did not account for scheduled maintenance actions (though the forecast could change based on maintenance actions after they occur). For days when website use data were available, the threat forecasts could be separated into storm and non-storm days. A summary of road segment threat forecasts is listed in Table 5-2.

Table 5-2. Threat Forecast Data (1/31/15 – 4/8/15)

Statistic	Storm Days	Non-Storm Days
Total Number of Threat Forecasts Issued	39,332	57,673
Total Segment Hours	84,456	250,884
Time Active Threat Existed	46.6%	23.0%
Average Threat Forecasts Issued (per segment per day)	11.18	5.52

Source: SDDOT

Because each segment could have a threat forecast issued at some point for every hour, the total segment hours represent the maximum number of hours for which threat forecasts across the statewide road network could have been issued. Dividing the number of actually-issued forecasts across all segments by the total number of segment-hours yields the percentage of time forecasts were issued. This percentage is labeled as "Time Active Threat Existed" in Table 5-2. On storm days, a given segment on a given hour was expected to have a threat forecast issued 46 percent of the time (11.18 threat forecasts per segment per day). The corresponding statistic for non-storm days was observed to be approximately 23 percent (5.52 threat forecasts per segment per day). Therefore, a threat forecast on the same segment was more than twice likely to be made on a storm day than on a non-storm day.

Based on the threat forecast logs, more threat forecasts were available for public consumption on storm days than non-storm days. Additionally, a significant number of threat forecasts were issued on storm days indicating an improvement in the number of travelers that are informed of potentially dangerous driving conditions.

It is of interest to assess whether or not NWS Alerts were present on the same days storm forecasts were made. The best comparison looks at the number of hours when at least one NWS alert was present on a given roadway segment, and compare that against the number of hours of threat forecasts for the same segment. This comparison is shown in Table 5-3. The table shows that the average roadway segment had 7.15 hours of NWS alerts on storm days and 1.66 hours of NWS alerts on non-storm days. This is not surprising, considering storm days are expected to exhibit the type of weather that is likely to trigger a NWS alert. The average roadway segment had 11.18 threat forecasts issued on storm days and 5.52 threat forecasts issued on non-storm days. On both storm days and non-storm days, there were on average four more threat forecasts issued than NWS alerts. This observation indicates that threat forecasts appear to have been issued during times when weather conditions that might have triggered an NWS alert is imminent or occurring. If threat

forecasts were issued before NWS alerts are issued for an impending storm, this could help to explain why there were more threat forecasts than NWS alerts.

Table 5-3. Average Daily Threat Forecasts and Average Daily NWS Alert Hours (1/31/15 – 4/8/15)

Statistic	Storm Days	Non-Storm Days
Total NWS Alerts (hours)	24,808	17,296
Average NWS Alerts (hours per segment per day)	7.15	1.66
Total Number of Threat Forecasts	39,332	57,673
Average Threat Forecasts (hours per segment per day)	11.18	5.52
Average Difference	4.03	3.86

Source: SDDOT

In conclusion, there were on the order of one hundred thousand threat forecasts issued during the period from January 31 to April 8, 2015. This wealth of information was made available through SDDOT traveler information dissemination sources. Furthermore, on average, more threat forecasts were made on storm days than on non-storm days, indicating more information was provided during storm days and when more people were accessing the website for information.

5.4.3 Website/Mobile Application Use

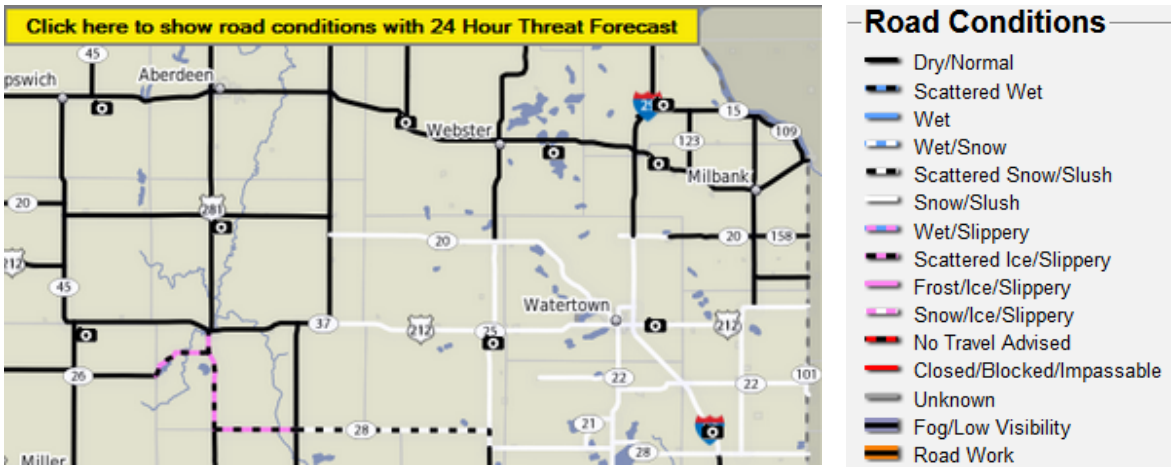
The next assessment focuses on the amount of road condition threat forecast information and NWS warnings that were accessed by the public. Use statistics were obtained for the website and categorized by web use and mobile application use. Information was collected for each distinct selection of map icon, map road segment, camera, and overlay.

Users can view roadway segment weather information by selecting a roadway link from the webpage. The road segment selections are, therefore, of particular interest for analyzing the dissemination of road condition threat forecast information.

A segment has two options as having a threat forecast or not having one. A threat forecast provides information about conditions that may adversely affect the roadway over the next 24 hours. The SDDOT MDSS system is used to predict threats, such as hazardous road conditions, precipitation, and blowing snow.[3]

Roadway segments can be selected from two map views. The **Road Conditions** map view, shown in Figure 5-4, is presented as the default page to users navigating the webpage. It provides a legend to denote roadway surface condition.

[3] http://www.safetravelusa.com/sd/threat_forecast.html



Source: SDDOT

Figure 5-4. Road Conditions Map View and Road Conditions Legend

Users navigate to the **Threat Map View** by selecting the *24 Hour Threat Forecast with Road Conditions* radio button in the upper right corner or by clicking on the yellow banner that appears at the top of the *Road Conditions* map. This banner, shown in 5-4, only appears when one or more segment road condition threat forecasts have been issued. Once the threat map view is selected, a user does not need to select a roadway segment to know a threat forecast has been made for a particular segment. Roadway segments with threat forecasts are highlighted automatically on the threat map view as shown in Figure 5-5.

Source: SDDOT

Figure 5-5. 24-Hour Threat Forecast Map View and Road Conditions Legend

Regardless of whether a roadway segment is selected from the Road Conditions map view or the 24-Hour Threat Forecast map view, the user is always provided with current surface condition information and a weather forecast. Where available, information regarding threat forecasts, NWS alerts, construction, and restrictions is also provided.

Table 5-4 shows the 24-Hour Threat Forecast Map base layer selection usage statistics. The threat layer was selected 3.7 more times on storm days than on non-storm days. However, considering the

number of visitors to the webpage, the per-person use (per person per day, as shown in the last row of Table 5-4) rate was observed to be more even, although on storm days users were approximately 1.6 times as likely to select the threat layer than on non-storm days.

Table 5-4. Usage Statistics for 24-Hour Threat Forecast Map Base Layer Selections (1/31/15 – 5/12/15)

Statistic	Storm	Non-Storm	All Days
24-Hour Threat Layer Total Number of Selections	44049	11867	55916
Total Days	20	82	102
Total Visitors	337302	144255	481557
24-Hour Threat Layer Average Number of Selections (per person per day)	0.131	0.082	0.116

Source: SDDOT

Visitors to the website on storm days viewed 3.46 times as many route segments to get conditions than visitors on non-storm days. This does not take into account which map the user was viewing for the segment data (Road Conditions or 24-Hour Threat Forecast map view).

The total and average route segment selections from the website are summarized in Table 5-5 and Table 5-6, respectively, and the ratio of average segment selections between storm and non-storm days is summarized in Table 5-7.

Table 5-5. Web-based Route Segment Selection Data (1/31/15 – 5/12/15)

Map View	Storm Days			Non-Storm Days		
	Threat Forecast			Threat Forecast		
	Yes	No	Total	Yes	No	Total
24h Threat Forecast	16,884	8,334	25,218	2,578	1,630	4,208
Road Conditions	167,890	81,565	249,455	14,011	15,771	29,782
Total	**184,774**	**89,899**	**274,673**	**16,589**	**17,401**	**33,990**

Source: SDDOT

Table 5-6. Web-based Route Segment Selections Per Person (1/31/15 – 5/12/15)

Map View	Storm Days			Non-Storm Days		
	Threat Forecast			Threat Forecast		
	Yes	No	Total	Yes	No	Total
24h Threat Forecast	0.050	0.025	0.075	0.018	0.011	0.029
Road Conditions	0.498	0.242	0.740	0.097	0.109	0.206
Total	**0.548**	**0.267**	**0.815**	**0.115**	**0.120**	**0.235**

Source: SDDOT

Table 5-7. Ratio of Web-based Route Segment Selections per Person (Storm Days:Non-Storm Days) (1/31/15 – 5/12/15)

Map View	Threat Forecast		
	Yes	No	Total
24h Threat Forecast	2.80	2.19	2.56
Road Conditions	5.12	2.21	3.58
Total	**4.76**	**2.21**	**3.46**

Source: SDDOT

On average, more users selected the threat forecast layer on storm days. This may indicate that users access the website and were interested in viewing threat data during inclement weather. This may be in part due to the presence of the yellow banner when threat forecasts were available. However, more detailed data would be needed to confirm the precise reason for this observation. Furthermore, the data indicate that website users accessed significantly more roadway segment information (on a per-user basis) on storm days than on non-storm days. Most of this increase can be attributed to the increase in selection of segments that had threat forecasts from the Road Conditions map view. Not only was more road weather information made available to travelers, but also, on average more road weather information was accessed by travelers during storm days.

Mobile segment selection statistics were also obtained. It is worth noting that the mobile segment selections per user were significantly lower than segment selections on the web. However, mobile users were less likely to select a segment that did not have a threat forecast from the road conditions layer on storm days. Similar to web users, mobile users were more likely to select a segment with a threat forecast from the road conditions layer on a storm day than on a non-storm day.

Mobile users selected approximately twice as many roadway segments on storm days than on non-storm days. The total and average route segment selections from mobile devices are summarized in Table 5-8 and Table 5-9, respectively, and the ratio of average segment selections between storm and non-storm days is summarized in Table 5-10.

Table 5-8. Mobile Device-based Route Segment Selection Data (1/31/15 – 5/12/15)

Map View	Storm Days			Non-Storm Days		
	Threat Forecast			Threat Forecast		
	Yes	No	Total	Yes	No	Total
24h Threat Forecast	680	121	801	186	40	226
Road Conditions	3,549	618	4,167	474	352	826
Total	4,229	739	4,968	660	392	1,052

Source: SDDOT

Table 5-9. Mobile Device-based Route Segment Selections Per Person (1/31/15 – 5/12/15)

Map View	Storm Days			Non-Storm Days		
	Threat Forecast			Threat Forecast		
	Yes	No	Total	Yes	No	Total
24h Threat Forecast	0.019	0.003	0.022	0.012	0.002	0.014
Road Conditions	0.098	0.017	0.115	0.029	0.022	0.051
Total	0.117	0.020	0.137	0.041	0.024	0.065

Source: SDDOT

Table 5-10. Ratio of Mobile Device-based Route Segment Selections Per Person (Storm Days:Non-Storm Days) (1/31/15 – 5/12/15)

Map View	Threat Forecast		
	Yes	No	Total
24h Threat Forecast	1.62	1.34	1.57
Road Conditions	3.32	0.78	2.24
Total	2.84	0.84	2.10

Source: SDDOT

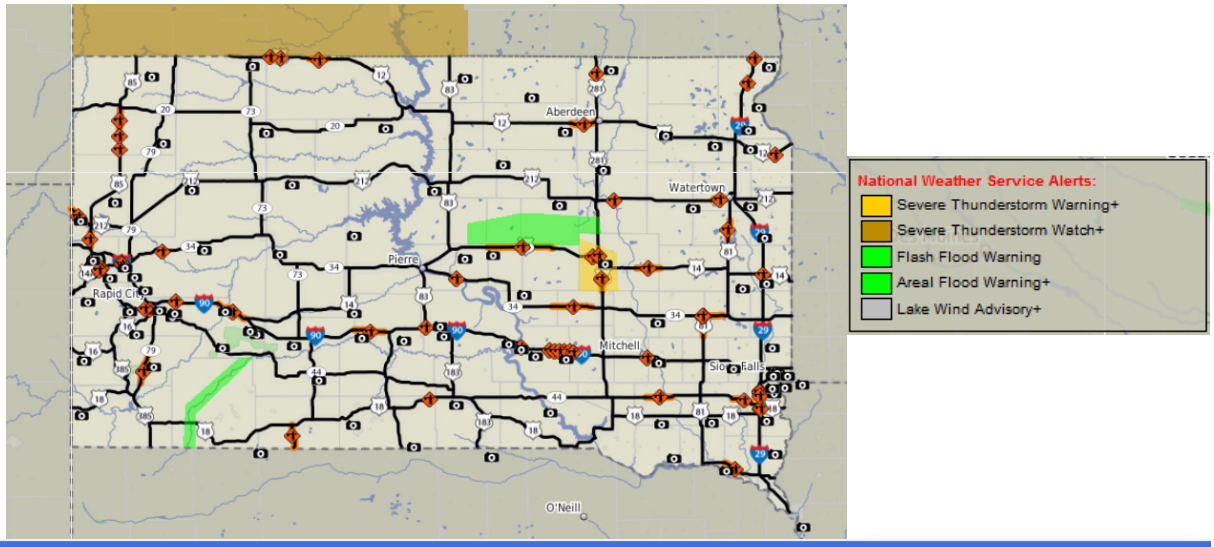
A significant amount of information was disseminated to the public through the website and mobile phone applications. The website was accessed nearly five hundred thousand times during the period of analysis from January 31 through May 12, 2015. Approximately fifty thousand website visitors viewed the 24-hour threat layer. The number of visitors who viewed the 24-hour threat layer was slightly higher for storm days (13 percent) than for non-storm days (8 percent). Furthermore,

approximately three hundred thousand segments were selected by website users and six thousand segments were selected by mobile users during the data collection period. This assessment shows that not only was a wealth of information made available to the public, but also it was extensively accessed.

5.4.4 NWS Warnings

The map also contains a layer for NWS Alerts. When the webpage is first loaded, the weather service alerts are not shown on the map by default. When the *National Weather Service Alerts* radio button is selected under overlays in the top right of the page, road segments that have an active alert are displayed on the map. The segments are colored based on the type of alert. As can be seen in the example shown in Figure 5-6, a flash flood warning and severe thunderstorm warning are present along US14. The active alert is displayed to the users when they select the US14 segment that passes through the warning area.

Data are also maintained on NWS Alert layer selections as well as NWS products (e.g., watch, warning, advisory etc.) that are posted for each roadway segment. Table 5-11 lists the total number of times the NWS Alert layer was selected and the number of times the layer was selected per person during both storm and non-storm days.



US-14 between Pierre and Huron

NWS Alerts	The following National Weather Service product is in effect: Severe Thunderstorm Warning between Wessington and 3.7 mi W of Junction South Dakota 37-Huron until 3:45 PM CDT. **National Weather Service product messages:** Severe Thunderstorm Warning message (1) Flash Flood Warning message (1)
Conditions	Road conditions are as follows: normal seasonal driving conditions.
Construction	The following road construction projects are in progress: • from 11 miles west of Junction South Dakota 47-Highmore to 0.50 mile east of Junction South Dakota 45 South - paving with width limit 18 ft, flaggers, delays 15 minutes, and pilot car until further notice; • from 4 miles east of Wessington to Junction US 281 North - pavement repair with width limit 18 ft, flaggers, delays 15 minutes, and pilot car Monday through Saturday until further notice.
Restrictions	Restrictions include: • from 11 miles west of Junction South Dakota 47-Highmore to 0.50 mile east of Junction South Dakota 45 South - width limit 18 ft until further notice; • from 4 miles east of Wessington to Junction US 281 North - width limit 18 ft Monday through Saturday until further notice.
Weather	The forecast until 9:00 PM CDT on Friday, June 19: Skies will be partly clear becoming partly cloudy. Visibility will be ten miles. Scattered thunderstorms. Winds will be 14 mph gusting to 27 mph from the south changing to 13 mph gusting to 28 mph from the south-southeast. Temperatures will range from 77 to 83 F increasing to 79 to 89 F.

Source: SDDOT

Figure 5-6. National Weather Service Alert Layer

Table 5-11. NWS Alerts Layer Usage Statistics (1/31/15 – 5/12/15)

Statistic	Storm	Non-Storm	All Days
NWS Alerts Layer Selected (Total)	6,415	3,068	9,483
NWS Alerts Layer Selected (Average) (per person per day)	0.019	0.021	0.020

Source: SDDOT

On a per-person basis, users selected the NWS Alerts layer at the same rate during both storm days and non-storm days. This may be partially due to the fact that a special banner was not displayed at the top of the map when NWS alerts were available. It may also be due to the fact that alerts could be issued in advance of a weather event that did not occur on storm days. As described previously, winter weather is a defining characteristic of storm days. Some alerts were issued on a storm day, while other alerts, primarily watches and advisories, were issued well in advance of the storm. Furthermore, some of the weather alerts were not necessarily winter-weather related (for instance, a wind watch or warning). An assessment of the types and duration of NWS alerts issued may assist in explaining this behavior.

The NWS products posted on South Dakota road segments are listed in Table 5-11, along with the total active duration time of each product. Multiple alerts may have been issued on the same segment at the same time. Because the total reflects the amount of time one or more of the alerts were active, it does not equal the sum of durations of all alerts.

Between the dates of 1/31/15 and 5/12/15, road segments had an average of one or more alerts for 7.2 hours per day on storm days and 1.8 hours per day on non-storm days. The information in Table 5-12 shows that two of the most active NWS alerts on storm days were Winter Weather Advisories and Winter Storm Warnings. The NWS defines a Winter Weather Advisory as a product "issued by the NWS when a low pressure system produces a combination of winter weather (snow, freezing rain, sleet, etc.) that present a hazard, but does not meet warning criteria" while a Winter Storm Warning is defined as a product "issued by the NWS when a winter storm is producing or is forecast to produce heavy snow or significant ice accumulations[4]."

[4] http://www.nws.noaa.gov/glossary/index.php?word=Winter+Weather+advisory

Table 5-12. NWS Alerts Issued (1/31/15 – 5/12/15)

NWS Alerts Name	Storm		Non-Storm	
	Total Duration (hours)	Average Duration (hours per segment per day)	Total Duration (hours)	Average Duration (hours per segment per day)
Air Quality Advisory	190	0.046	610	0.036
Areal Flood Advisory	0	0	219	0.013
Areal Flood Warning	0	0	306	0.018
Blizzard Warning†	2,091	0.505	0	0
Blizzard Watch	54	0.013	0	0
Dense Fog Advisory	2,004	0.484	0	0
Flash Flood Warning†	55	0.013	0	0
Flood Warn. Forecast Point	74	0.018	696	0.041
Freeze Warning	0	0	2,760	0.163
Freezing Rain Advisory	3,141	0.759	296	0.017
Frost Advisory	924	0.223	851	0.050
High Wind Warning	0	0	2,327	0.137
High Wind Watch	0	0	672	0.040
Severe Thunderstorm Warning†	150	0.036	186	0.011
Severe Thunderstorm Watch	0	0	24	0.001
Tornado Warning†	95	0.023	0	0
Tornado Watch	510	0.123	0	0
Wind Advisory	2,988	0.722	14,529	0.856
Wind Chill Advisory	9,976	2.410	5,710	0.336
Wind Chill Warning	260	0.063	182	0.011
Winter Storm Warning†	**4,353**	**1.051**	**420**	**0.025**
Winter Storm Watch	305	0.074	1,348	0.079
Winter Weather Advisory	**7,045**	**1.702**	**638**	**0.038**
Total*	29,805	7.199	30,207	1.780

*Multiple NWS Products may be issued simultaneously for the same roadway segment.
† NWS alerts previously reported on South Dakota traveler information systems

Source: SDDOT

The number of hours (i.e. a number between 1 and 24 hours) when a Winter Weather Advisory and or Winter Storm Warning was issued on each segment for each day was logged and available. Because a date was attributed to each segment Winter Weather Advisory and Winter Storm Warning, the duration of these alerts on storm days can be compared to the duration of the alert issues on non-storm days on the same segment. The data shows that there were nearly 11 times as many Winter Weather Advisory hours and 10 times as many Winter Storm Warning hours issued on storm days (7,045 segment hours) than on non-storm days (638 segment hours). This is not surprising considering the relationship between website visits (which define storm days) and snowfall or freezing rain, as illustrated previously in Figure 5-3.

Furthermore, controlling for the duration of storm and non-storm periods and the number of segments, it was found that on a storm day, a given segment was expected to have an average of 1.7 hours of advisories listed, versus an average of 0.038 hours for non-storm days. The corresponding values for Winter Storm Warnings are 1.05 on storm days and 0.025 on non-storm days, respectively. Thus, the duration of Winter Weather Advisories posted on roadway segments on storm days was about 46 times greater than on non-storm days, while the duration of WSWs the value is about 42 times greater on storm than on non-storm days. This observation confirms firmly that the alerts were being provided when users needed them the most—on storm days.

5.4.5 Conclusion

Measures of effectiveness calculated in the assessments in this section overwhelmingly support the hypothesis that expanded information has been provided to travelers. A wealth of threat forecast information and NWS alert information was posted to the SafeTravelUSA website. Furthermore, the assessments indicate that the information is also being accessed by the public. Also of interest is that the public accessed the website more on storm days than on non-storm days. However, on storm days, many more NWS alerts and 24-hour threat forecast data were available, and the average user accessed more of these data products than on non-storm days.

A summary of the measures of effectiveness and the analysis results are presented in Table 5-13.

Table 5-13. Summary of Assessment Results

MOE	Statistic	Storm	Non-Storm	Total	Ratio (S:NS)
Road Condition Forecast Provided	Total Number of Threat Forecasts Issued	39,332	57,673	97,005	-
	Average Number of Threat Forecasts Issued (per segment per day)	11.18	5.52	6.94	2.03
	Route Segment Selections Total	274,673	33,990	308,663	-
	Route Segment Selections Average (per person per day)	0.815	0.235	0.641	3.46
NWS Alerts Provided	NWS Alerts Layer Selected Total	6,415	3,068	9,483	-
	NWS Alerts Layer Selected Average (per person per day)	0.019	0.021	0.020	0.90
	NWS Alert hours per segment per day	7.20	1.78	2.84	4.04
	Total WWA Segment Hours	6,328	638	6,966	-
	WWA Hours per segment per day	1.70	0.038	0.364	46
	WSW Hours per segment per day	1.05	0.025	0.226	42

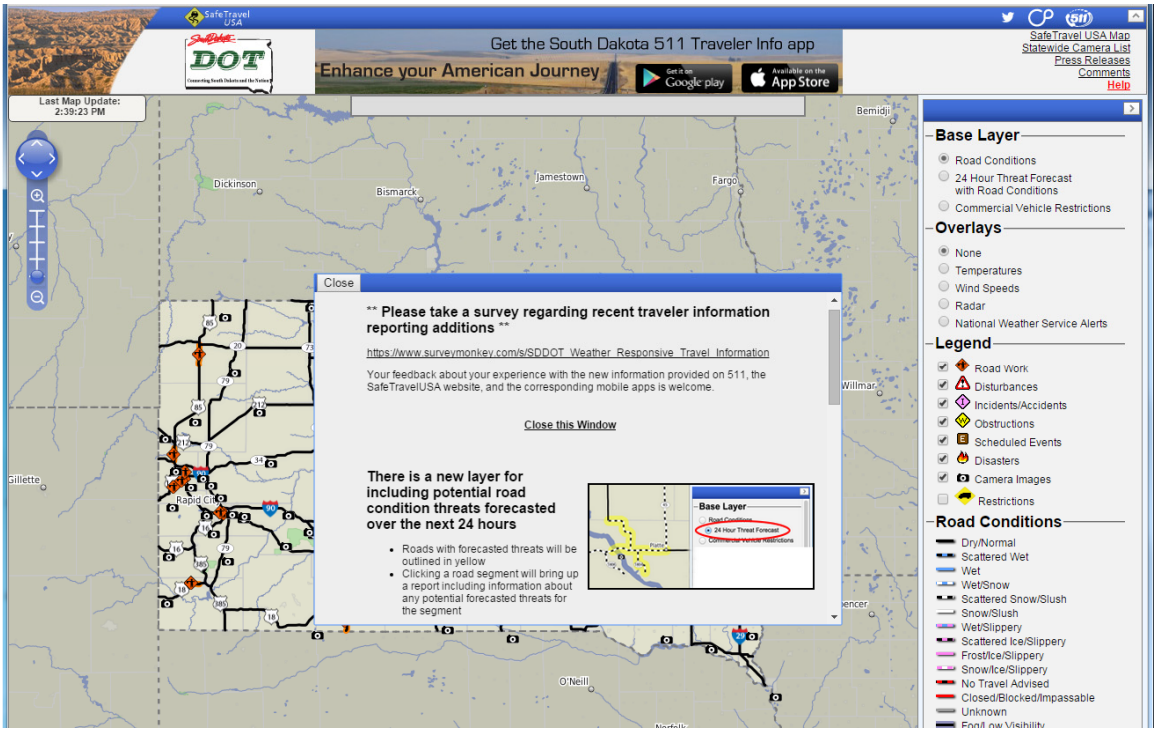
Source: SDDOT

The number of roadway condition threat forecasts and NWS alerts made available to the public was significantly increased. Additionally, this increased amount of information was accessed by the public in greater quantities and more often on storm days when travelers rely on this information the most. Overall, the hypothesis can be confirmed—the project improved and expanded road weather information provided to travelers in South Dakota.

5.5 Travelers' Impressions of Expanded Information (Hypothesis 4)

It has been previously discussed that a significant amount of new information was provided to travelers on the SDDOT website, 511 phone system, and mobile smartphone applications. The goal of Hypothesis 4 was to measure travelers' impressions. To accomplish this, SDDOT initiated an internet survey (using Survey Monkey software) that was posted on the SafeTravelUSA website. The survey asked about travelers' use of the new information from the website, 511 phone, and/or mobile smartphone applications. The survey was active on the website for approximately 2 months, from March 19, 2015 to May 14, 2015. SDDOT received 345 responses during that time. It was determined that a banner that was presented to the users upon their arrival on the webpage requesting their participation in the survey encouraged responses, which resulted in a robust response rate. The banner is shown in Figure 5-7. Of the 345 respondents, 164 indicated that they

had previously used the mobile smartphone application to gain traveler information and 106 indicated that they had called the 511 phone line during the previous two- month period.



Source: SDDOT

Figure 5-7. Flashing Banner Asking Users to Take the Internet Survey

The traveler survey involved questions that provided insight to the following:

- Awareness and viewing of the new road condition forecast threat information
- Ease of finding and understanding the new information
- Usefulness of the format of the information presented
- How motorists travel plans were affected after reviewing new information

5.5.1 Awareness

As described previously, the design of the upgraded SafeTravelUSA website included a new yellow banner at the top indicating when road condition forecast threats were present in South Dakota. This banner intended to focus users' attention on this new information when it was available. Due to this feature, a significant number of website users said they were aware and "viewed" the 24-hour road condition threat forecasts. Additionally, a fair number, albeit a smaller percentage, of users also were aware of this new information on the smartphone applications and 511 phone system.

Table 5-14 provides the survey results to the question "Did you view the 24-hour road condition threat forecasts?" These responses indicate that there was a strong interest in the 24-hour road condition threat forecast information. When the interest levels were compared for the web and 511/mobile application users, the responses were not as strong when receiving information via smartphone or

511. SDDOT could further investigate how the information on these other two media could be emphasized.

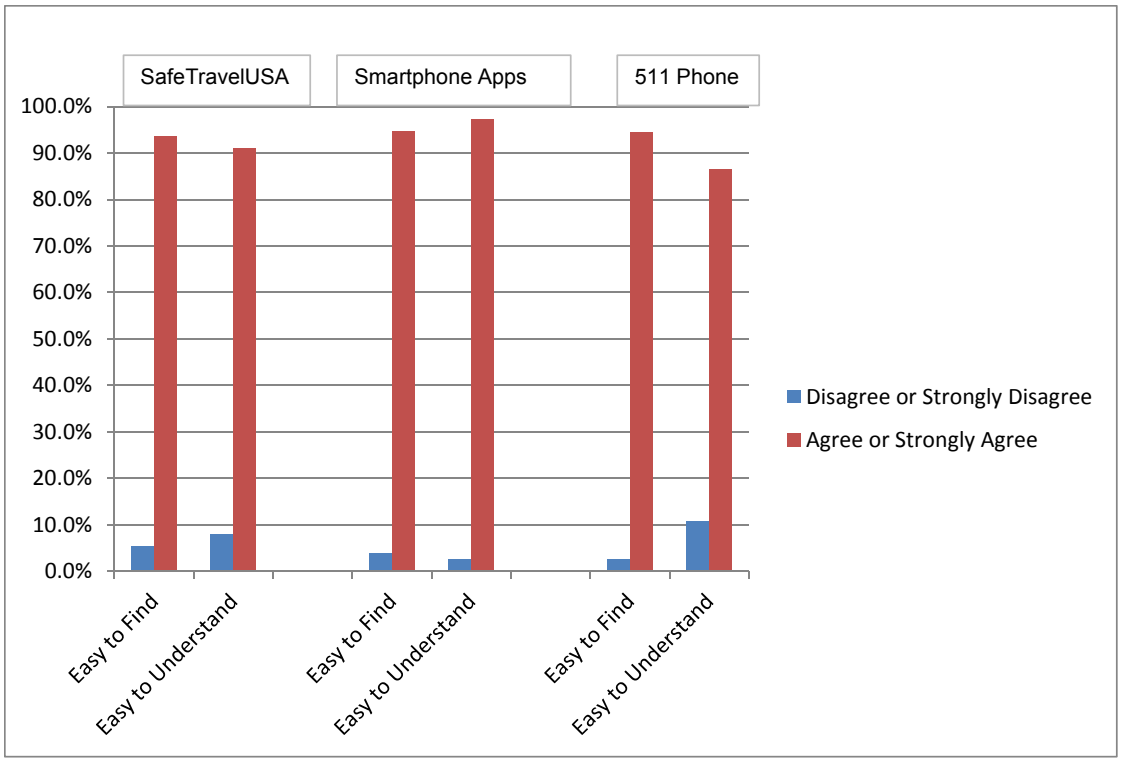
Table 5-14. Summary of Survey Responses Regarding Awareness of the 24-hour Road Condition Threat Forecasts

Question: When visiting the SDDOT traveler information source, did you view or listen to the 24-hour road condition threat forecasts?			
Answer Choice	**SafeTravelUSA**	**Smartphone Apps**	**511 Phone**
Yes	67%	49%	36%
No, I did not notice the 24-hour threat information	18%	28%	41%
No, I noticed the 24-hour threat information but did not view/listen to it	15%	23%	23%

Source: SDDOT

5.5.2 Ease of Finding and Understanding

Those who viewed the information were asked to indicate their degree of agreement with two statements related to ease of finding and ease of understanding the information. The results for each of the three dissemination media are shown in Figure 5-8.



Source: Battelle/McFarland Management, data from SDDOT

Figure 5-8. Summary of Survey Response Regarding Ease of Finding and Understanding the 24-Hour Road Condition Threat Forecasts

The percentages in Figure 5-8 reflect the number of respondents that disagreed and strongly disagreed, or agreed and strongly agreed with the statements. It is clear that the vast majority of respondents either agreed or strongly agreed that the information was both easy to find and easy to understand as presented on the website, smartphone, or listened to on 511. Slightly fewer respondents were pleased with their understanding the information delivered to them on the 511 phone system. This is understandable as it is more challenging to deliver any information over the phone–especially with this kind of detailed weather-related information. Approximately 1 percent of respondents in each case chose the "Don't Know" option.

5.5.3 Usefulness

To measure the usefulness of the 24-hour road condition threat forecasts, the survey asked the respondents to rate the following information:

- Highlighted yellow highway segments on the state map where threats are forecasted (website and mobile smartphone apps only)
- Text descriptions of the nature of the threat
- Text descriptions of the expected timeframe of the threat

The response categories included: not at all useful, somewhat useful, quite useful, very useful, and don't know. The results (percent of number of responses) are shown in Table 5-15 below.

Table 5-15. Summary of Survey Response Regarding Usefulness of the 24-Hour Road Condition Threat Forecasts

Responses	Somewhat Useful	Quite or Very Useful
SafeTravelUSA Website		
Highlighted yellow highway segments	12.8%	85.8%
Text – nature of threat	11.0%	82.6%
Text – timeframe of threat	12.0%	81.5%
Smartphone Apps		
Highlighted yellow highway segments	13.0%	87.0%
Text – nature of threat	13.3%	85.3%
Text – timeframe of threat	11.7%	86.0%
511 Phone		
Highlighted yellow highway segments	N/A	N/A
Text – nature of threat	16.7%	80.7%
Text – timeframe of threat	8.6%	85.7%

Source: SDDOT

The "Not At All Useful" responses ranged from 0 percent to 3 percent and the "Don't Know" responses ranged from 0 percent to 6 percent of the total number of responses. The range of the results was fairly close with a strong favor toward the information being useful to the respondents, regardless of which method they used to receive it. The 511 phone system users were slightly less supportive of the usefulness.

5.5.4 Affected Travel Plans

Probably the most revealing responses came when the internet survey respondents were asked "Please indicate the degree to which the 24-hour road condition threat forecast information has affected you travel plans." Available responses included:

- I have changed the timing of one or more trips
- I have changed the routing of one or more trips
- I have felt more prepared for one or more of my trips

This question was asked of all respondents regardless of whether they received their information from the website, smartphone, or a 511 call.

The response options included: strongly disagree, disagree, agree, strongly agree, and don't know. Figure 5-9 illustrates the percent of respondents that replied with the changed timing, changed routing, or felt more prepared responses, respectively.

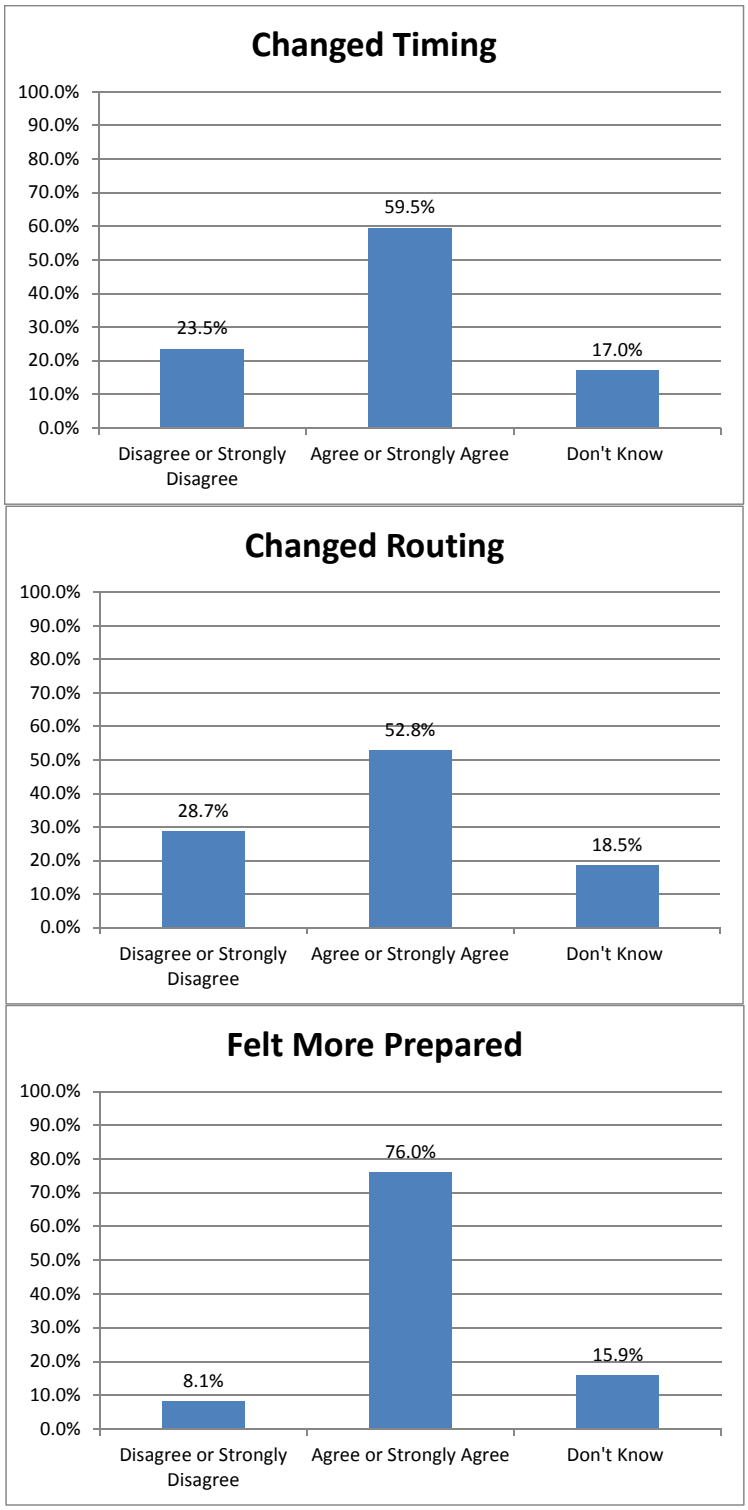
As summarized in the figures, it is clear that the 24-hour threat forecast information provided by SDDOT to travelers directly impacted their travel decisions. Approximately 25 percent of the respondents did not change their timing or routing of their trips and most likely traveled as originally planned. However, over 50 percent of respondents indicated that either they changed their travel timing or routing (or both) based on receipt of the 24-hour threat forecast information.

Additionally, over 75 percent of respondents indicated that they felt more prepared during their travel. This suggests that many of the travelers who took their trips as planned felt more prepared for the conditions. These are significant findings and it can be implied that those decisions either improved the travelers' level of safety (by not exposing themselves to unsafe travel conditions) or at least helped them to feel more prepared for the conditions.

5.6 Partner Agency Benefits (Hypothesis 5)

Evaluation timeframes did not allow for recruitment and direct input from SDDOT partner agencies. However, below are potential benefits other agencies might receive in the future if they are able to use the new traveler information.

- Agencies whose employees travel extensively could adjust travel schedules and routes to avoid periods involving 24-hour road condition threats. For example, employees of the SD Department of Human Services travel to meet with clients for providing services, or transporting them to locations where the required services are provided. Much of the travel occurs in remote areas of the state, including the State's nine Indian reservations. Knowledge of impending weather threats, particularly in winter months, could allow workers to adjust their trip schedule to ensure their own and their clients' safety.
- Agencies that deliver travel-related services could prepare and schedule for increased demand during periods of road condition threats. Knowledge of the anticipated locations and starting and ending times for the threats would help the State and local law-enforcement agencies and emergency responders allocate staff and resources to the areas and time periods where threats are predicted.
- In instances of severe weather events, advance knowledge of the road condition threats could help organizations decide whether to cancel conferences, athletic events, or other events requiring travel.



Source: Battelle/McFarland Management, data from SDDOT

Figure 5-9. Summary of Survey Responses Regarding Affected Travel Plans after Viewing the 24-Hour Road Condition Threat Forecasts

Chapter 6 – Conclusions, Lessons Learned, and Next Steps

6.1 Conclusions

Development, implementation, and evaluation of the South Dakota DOT Regional Traveler Information System for WRTM resulted in the following conclusions:

1. SDDOT's new data management and software systems have appeared to have worked well and produced a significant amount of new information that was provided to travelers through their website, 511 phone, and mobile smartphone dissemination tools.
    a. Nearly 100,000 24-hour road condition threat forecasts were issued during a relatively mild winter season. The average number of threat forecasts issued per road segment per day was over twice as much during storm days than non-storm days.
    b. National Weather Service alerts provided through the SDDOT traveler information dissemination methods equated to over 42,000 hours. The average number of hours when a NWS alert was also present was observed to be over four times greater during storm days than non-storm days.
2. It appeared that the traveling public was aware of the 24-hour road condition threat forecast information and obtained it when disseminated through the information channels. Based on the measured website and mobile phone use statistics, when the website use was compared to the mobile phone use, the vast majority of the information was obtained using the website with road condition hits equating to a ratio of over 50 to 1. Website usage statistics indicated that over 300,000 road condition views were made where road condition 24-hour threat forecasts were available. Of those approximately 10 percent of the views were specifically on the 24-hour threat forecast display.
3. Based on an internet survey of travelers in South Dakota, motorists responded positively to being asked about the awareness, ease of understanding, and usefulness of the 24-hour road condition forecasts.
    a. When asked if they viewed or listened to the forecasts, 67 percent of website users, 49 percent of mobile phone users, and 36 percent of 511 phone callers responded "yes."
    b. Survey respondents either strongly agreed or agreed 85 to 95 percent of the time to whether they thought the information was easy to find and easy understand, depending on the type of media they were using to view or listen to the information.
    c. 80 to 87 percent of the respondents found the information "quite" or "very" useful. This was evidenced by additional responses on how they used the information:
        i. Changed timing – 60 percent agreed or strongly agreed
        ii. Changed routing – 53 percent agreed or strongly agreed
        iii. Felt more prepared – 76 percent agreed or strongly agreed

4. Initial feedback from maintenance personnel suggest that the IRIS application on the plow truck MDCs is easy to use and will assist them to provide more frequent road condition reports during the next winter season.

6.2 Lessons Learned

The initial implementation of the South Dakota Regional Traveler Information System for WRTM was largely successful, but took longer to deploy than originally planned. This delay resulted in a lack of data to conduct the evaluation as originally planned. Additionally, the 2014-15 winter season was unseasonably warm and dry which resulted in fewer weather events from which to analyze data for evaluation.

Throughout the planning, development and implementation of the system the following lessons were learned:

1. Formation of the multi-disciplined Technical Panel was helpful to gain input and establish a strong partnership to successfully implement the project. The Technical Panel included SDDOT staff (maintenance and operations), NWS, and FHWA. The Panel was instrumental in providing input to the system concept and design elements such as the display of the new information on the webpage.
2. There were noticeable differences in user awareness of the 24-hour road condition threat forecasts depending on the type of media travelers were using to obtain the information. The website was the highest (67 percent), then mobile phone (49 percent), then 511 phone (36 percent). Although this result is intuitive and likely not surprising, perhaps more can be done to make travelers aware of this information when they are using a mobile phone or calling 511. SDDOT and their partners should investigate approaches to emphasize this information on these media.
3. The website display of the 24-hour road condition threat forecast information was very successful. Enhancements such as dividing forecasts into small intervals or displaying intensity (or seriousness) of forecasts with different colors on the map may be considered in the future to enhance the user experience. SDDOT, and their contractor Iteris, will continue to evaluate these and other possible enhancement to the web page displaying road condition threat forecasts.
4. Procedures for displaying road weather related messages on DMS were not in place to effectively implement that element of the project. In order to disseminate road weather messages on the DMS using input from the existing data systems, procedures will need to be created to implement these additional uses.

6.3 Next Steps – Future Expansion

South Dakota DOT found this initial implementation very informative and promising. Learning that travelers used the 24-hour road condition threat forecasts to influence their travel decisions is an important finding and will likely guide SDDOT's near-term decisions regarding how to move forward with these applications.

SDDOT is currently planning to enhance and expand the project based on what was learned during the initial implementation. Those plans include:

1. Continuing to provide 24-hour road condition threat forecasts on traveler information media.
    a. Display formats will be reviewed and possibly revised to make the information clearer and widely available
    b. The efforts will be expanded to publicize the availability of the new traveler information.
    c. Further evaluation will be conducted through continued monitoring of the use statistics and potentially repeating the Internet survey on the website.
2. Expanding the dissemination of the 24-hour road condition threat forecast information to partners and third party information providers. This may include the development of an XML feed of the information.
    a. The MDSS Pooled Fund Study work plan for the following year calls for the development of a standardized data structure for exporting MDSS-based data for importing into traveler information systems. This effort would facilitate the use of MDSS data (such as 24-hour road condition threat forecasts) to other member states in the pool.
3. Deploying IRIS application on the plow truck MDC. As of the date of this report, it is not known how extensive this deployment will be. SDDOT intended to make that decision in November 2015 prior to the upcoming winter season.
    a. This effort will include conducting an evaluation of the IRIS application on MDCs to report road conditions to measure the effectiveness. This may include executing a similar survey to what was accomplished during this project.
4. Developing and implementing procedures to display road weather related messages on SDDOT's DMS signs. This effort would utilize the system development accomplished as part of this project to provide the SDDOT operators possible DMS messages that could be displayed. SDDOT does not intend to automate message display on DMS at this time.

South Dakota DOT anticipates rolling out a more robust Regional Traveler Information System for WRTM for the 2015-2016 winter season based on the experience and lessons learned from this initial implementation.

Chapter 7 – Recommendations

Recent implementations of WRTM strategies by transportation agencies have been fairly successful. The South Dakota Regional Traveler Information System Project was no exception. SDDOT has stated that it will build upon this effort to continue to improve road weather management. Furthermore, FHWA is continuing its commitment to assisting agencies with WRTM strategy implementations to achieve the goals of the Road Weather Management Program. The following recommendations are intended to assist SDDOT and FHWA in their efforts to further advance the WRTM program and facilitate the development and deployment of WRTM strategies.

7.1 Recommendation #1 – Complete deployment of the IRIS application on the MDCs in SDDOT Plow Trucks

Due to the reasons explained previously in this report, the IRIS application was not fully implemented on the MDCs in the SDDOT plow trucks. SDDOT has indicated that the results of this evaluation will help determine how many of the approximately 100 trucks in the state fleet equipped with MDC computers will be set up with full in-truck conditions reporting capability. It is expected that this full deployment will generate additional benefits, based on the results from the expanded information to travelers and maintenance staff surveys after IRIS application testing. SDDOT should complete this deployment of the IRIS application on the MDCs and conduct an evaluation to understand the benefits.

7.2 Recommendation #2 – Continue Outreach and Education of Recent WRTM Strategy Implementation Successes to Other State DOT's

As a program, WRTM continues to be recognized around the U.S. as a set of strategies that can improve mobility and safety during weather events. The South Dakota DOT implementation provides evidence of the potential benefits of WRTM. However, much can still be accomplished to educate and encourage the state DOTs to conduct research and implement strategies that meet their specific needs. Where feasible, SDDOT and FHWA should continue to reach out to state DOTs and other agencies to inform them of the WRTM benefits, lesson learned, and future possibilities. This can be accomplished through newsletters and project flyers, presentations at relevant conferences and webinars, and conducting the bi-annual WRTM Workshop.

7.3 Recommendation #3 – Continue to Build on SDDOT's Successful Road Weather Condition Forecasting and WRTM Implementation

South Dakota is one of the states that are providing road condition forecasts to travelers. Travelers who responded to the survey indicated they want this level of information and make travel decisions based on road condition forecasts. SDDOT plans to continue to provide road condition forecasts on their traveler information systems (i.e. website, DMS, mobile apps) and deploy the IRIS application on the MDCs in their plow trucks. Efforts to evaluate the use and effectiveness of the IRIS application should continue within SDDOT. FHWA should continue to monitor the progress of their WRTM application and inform other agencies about these activities and accomplishments.

7.4 Recommendation #4 – Continue Research and Monitoring of Mobile Data Applications and Practices

WRTM mobile data applications and practices take on many different forms in various states depending on the states' specific needs. Additionally, the generated data are used to improve state DOT operations and traveler information dissemination in different ways. SDDOT focused on the operational improvement of road condition reporting and transmission, improved traveler information, and timeliness and accuracy of the resulting data. It should continue to monitor WRTM activities across the U.S., to identify strategies to improve its own road weather program. For example, the use of mobile sensing or connected vehicle data as input to road weather condition monitoring may be a potential avenue to improve road condition reporting, beyond sources requiring vehicle operator input. FHWA should continue to monitor and document best practices for WRTM mobile data and connected vehicle applications. Specifically, FHWA should continue to share what is learned or gleaned from state mobile data applications to help promote and encourage of the adoption of similar technology and systems in other parts of the Country.

APPENDIX A – List of Acronyms

Apps	Applications
ATIS	Advanced Traveler Information System
CVOs	Commercial Vehicle Operators
DMS	Dynamic Message Signs
DOT	Department of Transportation
FHWA	Federal Highway Administration
IRIS	Integrated Roadway Information System
ITS	Intelligent Transportation Systems
JPO	Joint Program Office
MDCs	Mobile Data Collectors
MDSS	Maintenance Decision Support System
MOEs	Measures of Effectiveness
NWS	National Weather Service
RWMP	Road Weather Management Program
SDDOT	South Dakota Department of Transportation
URL	Uniform Resource Locator
WRTM	Weather Responsive Traffic Management
WWA	Watch, Warning, Advisory
XML	Extensible Markup Language

APPENDIX B – Evaluation Plan

Evaluation Plan for the South Dakota DOT Weather Responsive Traffic Management (WRTM) Project

1.0 Introduction

This document describes the evaluation strategy for the South Dakota Department of Transportation (SDDOT) Weather Responsive Traffic Management (WRTM) system implementation. The evaluation plan explains the approach to measure overall project impacts, identifies five evaluation hypotheses, details the methodology by which each hypothesis will be tested, and outlines the necessary data to be used. This document will guide the efforts of SDDOT staff (and its contractor – Iteris) and FHWA (and its contractor – Battelle) to measure the impacts of the South Dakota WRTM project.

1.1 Project Description

The South Dakota Department of Transportation intends to enhance the capabilities of its existing Advanced Traveler Information System (ATIS) to improve its ability to provide valuable and reliable guidance to travelers and transportation support services during all hours of the day and seasons of the year. This section briefly describes the current data collection, processing, and traveler information systems, the proposed WRTM system elements, and the expected benefits.

1.1.1 Current System

The existing systems include:

- RWIS – the network of Environmental Sensor Stations (ESS) that collect road weather data and camera imagery
- Weather Center – value-added weather support service that provides road weather data and weather forecasts
- IRIS™ – the road condition data collection, integration, and display system
- MDC – the system that captures and manages data from SDDOT fleet vehicles
- PFMDSS – the system that integrates weather, treatment and road condition data to generate forecasts of road conditions and recommendations of maintenance actions
- ATIS – the system that ingests road condition and forecast information and delivers route-segment-specific information to travelers

The current SDDOT traveler information system collects road condition information provided by SDDOT field personnel using the Integrated Roadway Information System (IRIS™). The road condition information is supplemented by observations derived from the SDDOT Road Weather Information System (RWIS) and the national network of weather resources, camera imagery from SDDOT cameras, and weather forecasts provided by South Dakota's weather service provider. The source information is assembled into traveler information guidance formats and distributed to travelers via services including the SafeTravelUSA website, 511 telephony system, applications for mobile devices (apps), and ClearPath511 notification system.

On a growing portion of its winter maintenance trucks SDDOT supports its maintenance forces with mobile data collection (MDC) units, which provide road condition reporting capability plus information regarding a number of treatment parameters. The MDC information currently supports the pooled fund maintenance decision support system (PFMDSS) program. The PFMDSS is the culmination of a multi-state research project that integrates weather, treatment, and road condition data to generate forecasts of road conditions and recommendations of maintenance actions. The Iteris Weather Center manages all of these weather-related support programs as a cohesive package of services. Thus, all of the data currently used to support weather-related programs for SDDOT flows through a single processing center before going to SDDOT or its traveler constituents.

1.1.2 Proposed WRTM Project Elements

SDDOT has actively pursued ways to improve traveler information and has recognized that information available to its maintenance personnel through MDC and the PFMDSS could greatly enhance the traveler information program. The project strategy incorporates the road condition data from MDC and the analyses and forecasts of road conditions from the PFMDSS into a revised ATIS support package. Alerts of hazardous weather as provided by products from the National Weather Service (NWS) are also now reported for affected road segments. The enhancement strategy includes:

- The integration of road condition data from in-vehicle MDCs with the road condition reports from IRIS™. A webpage will be built by which drivers will be able to input road conditions for a selected road segment. The interface will mimic the IRIS™ GUI to the extent possible in order to address the incompatibilities in the up-front design rather than in the operational integration. Prioritization of reports will ensure that the latest conditions are valid regardless of source, meaning that for a given maintenance segment whatever conditions have been most recently reported will be active.
- The generation of roadway segment-specific road condition reports from analyses and forecasts. The road condition forecast modification will be displayed when the analyses or forecasts from the PFMDSS indicate conditions that are potentially more adverse than the currently reported conditions. The addition of road condition forecasts will become an extension in time of the reported road conditions. The forecasts will indicate possible deterioration in the conditions based upon the weather forecast and interaction of the pavement with

the forecasted conditions. The current road conditions and the weather forecast for each route segment will remain on the 511 system and in the text reports on the website and mobile apps. Supplemental information will be added to the message to indicate development of potentially adverse conditions.

- More extensive presentation of National Weather Service severe weather advisory messages. The project will establish guidelines for displaying a larger set of NWS severe weather advisories. Currently, high priority messages are delivered in brief reports via SafeTravelUSA, 511 telephony, and the mobile apps. This includes tornado warnings, severe thunderstorm warnings, flash flood warnings, blizzard warnings, winter storm warnings, and ice storm warnings. The intent is to look at additional products.
- Ongoing improvement in the content and presentation of apps for mobile devices. Travelers now have access to apps for both Android and iOS operating systems that are designed to provide the capabilities of the SafeTravelUSA website interface. This project will upgrade the apps in parallel with the website enhancements and consider app enhancements to improve delivery of information using this medium.
- Providing notifications to drivers via DMS. The use of DMS to provide advisories of weather related conditions of immediate local concern will be pursued.

The expected benefits of these WRTM project elements are described in Table B-1 below.

Table B-1. SDDOT WRTM Project Expected Benefits

WRTM Project Elements	Expected Benefits
• Enhance MDC capability to collect road condition data • Integrate MDC road condition data collected by plow driver with IRIS • Incorporate new MDC data into traveler information system	• Increased frequency of road condition data collection and reporting • Improved efficiency of inputting road condition information into IRIS • Improved satisfaction of plow drivers and maintenance supervisors with data collection/entry systems • Improved information to travelers
• Add road segment-based road condition forecasts (from PFMDSS) to traveler information systems and disseminate	• Improved segment-based road condition forecast development in PFMDSS • Expanded information (segment-based road condition forecasts) to travelers
• Add NWS severe weather warnings (selected) to traveler information dissemination systems	• Expanded information to travelers
• Enhanced mobile phone applications to provide new information as defined by this project and improve information delivery	• Improve methods to deliver and expand information to travelers
• Expand use of DMS to include road weather messages and NWS severe weather warnings	• Expanded information to travelers

As can be seen in the Expected Benefits column, much of the WRTM project goals are focused on expanding and improving road weather conditions and forecast information and providing them to travelers. These benefits are used as the basis for the evaluation hypotheses development, described later in this evaluation plan.

1.2 Evaluation Objectives

The analysis outlined in Section 2 of this plan is designed to evaluate the following hypotheses:

1. The project will improve efficiency of road condition data collection by SDDOT maintenance forces.
2. The project will increase the number and frequency of road condition reports.
3. The project will improve and expand road weather information provided to travelers.
4. Travelers on South Dakota roads will perceive benefits from the expanded/improved traveler information (e.g., are segment-level road condition forecasts valuable to travelers?).

5. Partner agencies in SD will benefit from the expanded/improved traveler information.

The evaluation will also help to guide future program development and expansion activities at SDDOT. Currently, SDDOT has approximately one-quarter of their plow trucks outfitted with the technology to support these activities. The evaluation of this initial implementation will assist SDDOT to refine the program and plan for future expansion and enhancements.

1.3 Document Organization

The following sections contain evaluation approach and details, as follows:

Section 2 – Evaluation Approach – identifies evaluation hypotheses, measures of effectiveness, and data needs to support analysis of project benefits

Section 3 – Risks and Mitigations – identifies project evaluation risks and possible approaches to mitigate the risks

Section 4 – Evaluation Schedule – provides key evaluation tasks and evaluation timeline

Section 5 – Roles and Responsibilities – defines the roles and responsibilities associated with executing the evaluation plan for SDDOT and FHWA

2.0 Evaluation Approach

This section describes the evaluation approach to be used to measure the SDDOT WRTM project benefits. It includes a discussion of how the hypotheses will be measured and identifies specific measures of effectiveness (MOEs), the data needed to support the analyses, and the analysis to be conducted to test each hypothesis.

Table B-2 provides a summary of the pertinent information to guide the evaluation. Hypotheses, MOEs, and data needs are listed. The evaluation will use both quantitative and qualitative analysis to test the hypotheses. The analysis methods will include both before-after and with-without approaches, as well as numerical/statistical techniques. The before-after analysis method will require that previous year data is available from which to make a comparison. The with-without analysis method will require that SDDOT identify similar geographic areas and weather conditions during the evaluation period where the project technology is not being used so valid comparisons can be made.

Table B-2. South Dakota WRTM Project Evaluation Approach

Hypothesis	Measures of Effectiveness	Data Needs
1. The project will improve efficiency of road condition data collection by SDDOT maintenance forces	• Expression of value from SDDOT maintenance staff regarding new processes and the resulting data	• Maintenance staff logged levels of system satisfaction during 2014-2015 winter (several times during the season) • Interviews with maintenance staff
2. The project will increase the number and frequency of road condition reports	• Number and frequency of road and weather condition reports (by segment) made in 2014-15 winter season – compare those equipped with the technology versus those not-equipped with the technology • System usage perceptions by Maintenance staff	• Newly created system logs • Interviews with maintenance staff
3. The project will improve and expand road weather information provided to travelers	• Number of road condition forecast content provided on webpage, 511 phone, and mobile apps	• Newly created system logs
	• Number of NWS severe weather warnings provided on webpage	• Newly created system logs
	• Number of road weather and NWS warning messages posted on DMS relative to the total possible number of messages posted	• Newly created system logs
4. Travelers on South Dakota roads will perceive benefits from the expanded/ improved traveler information (Are segment-level road condition forecasts valuable to travelers?)	• Expression of value from travelers regarding new information – traveler types include: ○ General travelers ○ Non-DOT state employees ○ CVOs ○ Other volunteers	• Website and phone hit statistics • Internet survey • Participant surveys
5. Partner agencies in SD will benefit from the expanded/ improved traveler information	• Input from other SD agencies or neighboring states indicate benefits were realized from WRTM generated information. Possible participants include: ○ SD Highway Patrol ○ Emergency Responders ○ Local law enforcement	• Interviews with partners

Qualitative analysis will consist of surveys and interviews of maintenance staff, internet users, travelers, partner agencies and neighboring states. The surveys and interviews will seek to gain an understanding of how the new systems benefited operations, and how the enhanced/expanded traveler information is being used to assist motorists with their situational awareness and key travel decisions.

The evaluation approach for each hypothesis is described below.

2.1 Hypothesis 1: The project will improve efficiency of road condition data collection by SDDOT maintenance forces

Currently, on-board mobile data computers (MDCs) installed on SDDOT snow plows help to collect road condition information. However, that information is not currently shared with the public and does not contain all the information needed. This project will change how the maintenance staff use the MDCs, and what information is collected. This information will be integrated with IRIS in order to communicate it to the traveling public through the many South Dakota traveler information dissemination approaches.

The goal is to improve the completeness and timeliness of the road weather condition data collection, the efficiency of inputting data into IRIS, and the satisfaction of maintenance staff in their efforts to collect and enter data. In addition, the system will have a more complete road weather dataset to better inform travelers.

The time saved by maintenance staff to collect and post the road weather conditions was considered as a quantitative measure for this hypothesis. Two reasons were identified that made this not possible: 1) it may actually take more time (not less) to collect and input information into the MDC because it is anticipated the MDC will be used more frequently to collect road condition information; and 2) no records are kept regarding the current time maintenance staff expend collecting and inputting data into IRIS. Therefore a quantitative assessment was deemed not practical. Instead, a qualitative approach will be used to understand how the new systems have assisted maintenance staff in the collection and posting of road weather condition information. Maintenance staff feedback logs will be prepared and completed by staff throughout the 2014-15 winter season. The logs will focus on: how the new system assisted maintenance staff in accomplishing their jobs, what challenges were observed, and in what instances it improved their operations. These logs will be completed periodically throughout the winter season in an effort to understand the progression of technology adoption and benefits realized.

Additionally, selected maintenance staff will be interviewed at the conclusion of the winter season to learn the benefits and challenges of project implementation. The results will assist SDDOT in making future refinements and improvements to the system.

2.2 Hypothesis 2: The project will increase the number and frequency of road condition reports

Currently, SDDOT maintenance staff collects this information and enters it into IRIS. When in IRIS, the information is immediately available to the public through the traveler information dissemination methods. Challenges with this current approach include the amount of time

required to enter the data, the lag in time between observations and data entry, and the limited frequency and geographical coverage of data collection.

The WRTM project will integrate the MDC data (also collected by snow plow drivers) with IRIS. This new system approach is anticipated to:

- Increase the number and frequency of road weather condition reports
- Shorten the time required to populate the IRIS database because the MDC data will now be automatically integrated into IRIS

The approach to measure this hypothesis will include quantitative and qualitative methods. Newly created system data logs will capture the number and frequency of road condition reports. Interviews with Maintenance staff will capture their perceptions of system usage and the potential for more timely collection of road condition data inputted into IRIS. This interview process will be coordinated with those activities planned in hypothesis 1 above.

The number and frequency of road weather condition reports for the 2014-15 winter season will be automatically collected by the system by those using the new technology and those that are not (with and without method). Comparisons will be made to determine if the new technology is yielding more reports, more frequently.

It is important to note that maintenance staff will not be required to use the new technology. The evaluation will attempt to determine if the new technology is indeed more efficient and effective at collecting and reporting road conditions.

2.3 Hypothesis 3: The project will expand and improve upon information provided to travelers

The vast majority of expected project benefits are related to providing expanded and improved information to travelers, as indicated in Table B-2 above. Expanded information includes:

- Segment-based road condition forecasts, coming from the PFMDSS system
- Increased number and frequency of road weather condition reports (as discussed above)
- National Weather Service severe weather warnings
- Road weather condition information on DMS signs

Improved information will be achieved through display and formatting changes to accommodate the expanded information on the websites, 511 phone system, DMS signs, and mobile applications.

The goal of the project is to provide meaningful and useful traveler information beyond what has been available in the past, portraying it in a clear and understandable format. Hypothesis 3 focuses on the quantitative assessments from system data logs (hypothesis 4 which focuses on the qualitative input from travelers, as described next).

Newly created system data logs will capture:

- Number of road condition reports, including forecast content, provided on webpages, 511 phone and mobile apps
- Number of NWS severe weather warnings provided on webpages, 511 phone system and mobile apps
- Number of road weather and NWS warning messages posted on DMS compared to the available/relevant conditions and warnings

These numerical results will be an indicator of the increased amount of expanded and improved information available to travelers. Since the information will all be new, no comparisons can be made with previous years. It is presumed that more information is better. The traveler's perceived benefits from the information will be determined in the next hypothesis below.

2.4 Hypothesis 4: Travelers on South Dakota roads will perceive benefits from the expanded/improved traveler information (Are segment-level road condition forecasts valuable to travelers?)

This hypothesis is established to qualitatively measure the benefits perceived by travelers from the various expanded/improved traveler information resulting from the WRTM implementation. The planned expansions of traveler information are listed earlier under hypothesis description.

Capturing information from the general public about traveler information systems is always challenging. Questions for which the evaluation intends to gain answers include:

- Were travelers aware of the new information on the websites, 511 phone, DMS, and mobile apps?
- Was the new information easy to find? If not, what improvements would they suggest?
- Were the format and display of the information easy to understand? If not, what improvements would they suggest?
- Which new information did they view or use the most?
- Did the new information help them make travel decisions? How?
- Were the specific segment-level road condition forecasts valuable? How so?

Responses to these questions will be obtained through website hit statistics, phone usage logs, Internet surveys, and participant surveys.

The following four traveler types have been identified:

1. General public
2. Non-DOT state employees
3. Commercial Vehicle Operators (CVOs)
4. Other volunteers (could include a select group of delivery services or general public)

The following Table B-3 outlines the approach to obtaining input from each traveler type:

Table B-3. Data Collection Approaches by Traveler Type

Traveler Type	Data Collection Approaches
General public	Website hit statistics, phone usage logs, Internet survey
Non-DOT state employees	Website hit statistics, phone usage logs, focused participant survey
Commercial vehicle operators	Website hit statistics, phone usage logs, focused participant survey
Other volunteers	Website hit statistics, phone usage logs, focused participant survey

Efforts to recruit individuals from each traveler type, with the exception of the general public, will be the responsibility of the SDDOT project team. The Internet and participant surveys will be developed at a later time and use the initial set of questions above as a starting point.

Results will be compiled and lessons learned documented.

2.5 Hypothesis 5: Partner agencies in SD will benefit from the expanded/ improved traveler information

In addition to the SDDOT staff and the current traveler information system users, other partners may benefit from the WRTM system implementation. Partners could include other South Dakota state/local agencies such as Highway Patrol, emergency responders, and local law enforcement agencies (police or sheriff departments).

This plan will attempt to involve other potential project partners and document any benefits they experience from obtaining and using the expanded and improved road weather information.

The data to support evaluation will be acquired through interviews with those partners. An interview form will be developed prior to the meetings that will include questions such as:

1. What is your organization and relationship to the SDDOT?
2. How do you currently use the SDDOT traveler information?
3. Of the traveler information enhancements added in the 2014-15 season, which did you find the most useful?
    a. Improved road weather condition information?
    b. Segment-level road condition forecasts?
    c. NWS severe weather warnings?
    d. Road weather and NWS warnings posted on DMS signs?
4. How did you use the new information to improve your operations? Please provide examples, if possible.

3.0 Risks and Mitigations

Table B-4 lists potential risks and constraints that may complicate the evaluation and make it difficult to obtain the anticipated results, along with some strategies to mitigate the risks.

Table B-4. Potential Project Risks and Constraints and Strategies used to Mitigate

Risks	Mitigation Strategy
There is a learning curve associated with any new technology. Maintenance staff might find the MDC webpage difficult to use at first.	The MDC webpage will be complete before project rollout, giving maintenance staff time to become accustomed to it. SDDOT intends to perform training for maintenance staff prior to the project rollout. This training will be in the form of webinars and teleconferences demonstrating the new system and opportunities for discussion. For maintenance staff, the first wave of system satisfaction logs will try to gauge whether they are becoming comfortable with the technology.
Employees might not feel able to share criticism of a project supported by their supervisors.	Employees will have the ability to make anonymous comments.
Much of this project is focused on expanded or improved traveler information. Traveler's input is critical to conducting a successful project evaluation. It may be difficult to recruit the right or enough volunteers to gather the information required.	SDDOT should begin to recruit traveler volunteers. Non-DOT state employees and CVOs should be a primary focus because these are known individuals. Other volunteers should also be recruited early. Identifying and describing the project to these volunteers will be an important task to assist the evaluation process.
Another important group to obtain information from is project partners – other state agencies. It may be difficult to assure their cooperation during the evaluation period.	SDDOT should identify and open a discussion with this group to learn who would be willing to participate and gain an understanding of their potential interests and usage of the information.
It will be important to evaluate with and without technology conditions within a maintenance unit (and adjacent units) for similar storm and road conditions. This may be difficult to ensure.	SDDOT will work with NWS (a project stakeholder) ensure similar conditions existed in specific geographic areas for comparison purposes.
Much of the quantitative data will be generated automatically by the newly developed system logs to support the evaluation. The information from the logs may not fully support the intent of the evaluation.	The SDDOT system developers (Iteris) should work closely with the evaluation team to develop and structure the system logs to ensure they include the needed evaluation data.
Internet survey may not yield the expected responses and data necessary to evaluate general traveler's perceptions.	SDDOT and Battelle will work together to develop a brief but meaningful survey instrument that website users will be asked to complete. Also, the survey will be prominently displayed on the website so users are aware that the DOT needs their help. If the Internet survey is not effective, the evaluation team may need to reconsider the Focus Group approach to gather information from general travelers.

4.0 Evaluation Schedule

The finalized Evaluation Plan will be completed in October 2014, and evaluation activities will begin with full system implementation in November 2014. A detailed evaluation task schedule is shown in Table B-5.

Table B-5. Evaluation Schedule by Task

Task	Completion Dates
Complete Evaluation Plan	October 2014
Prepare data collection instruments (logs, surveys, interview guides, etc.)	October 2014
Recruit South Dakota traveler volunteers (Non-DOT state employees, CVOs, and others)	October 2014
System development complete and begin testing	October 2014
SDDOT maintenance staff training and project initiation	November 2014
Quantitative Data Collection for 2014-2015 Winter Season	November 2014 – April 2015
Conduct Debrief and Offer Additional Training, as needed	[After first winter event]
Conduct Preliminary Quantitative Comparative Analysis	November – December 2014
Submit Preliminary Analysis Findings	January 2015
Conduct Quantitative Analysis	January 2015 – May 2015
Conduct Surveys*	March 2015
Conduct Qualitative Analysis (interviews, per evaluation plan)*	May 2015
Submit Final Evaluation Report	August 2015

* It may be advantageous to conduct qualitative analyses following winter weather events instead of waiting until the end of the season. These dates indicate the activity will have to be completed by this timeframe.

5.0 Roles and Responsibilities

The execution of the evaluation activities described in this plan will be a joint effort conducted by SDDOT, its contractor (Iteris, Inc.) and the FHWA Technical Support Contractor (Battelle). This chapter describes the responsibilities of each party.

The development of this Evaluation Plan was a joint effort by SDDOT, Iteris, Inc. and Battelle. It describes hypotheses to be tested, measures of effectiveness to be used, and data collection needs. Using information from the SDDOT developed Operations Concept and several discussions with the SDDOT project team, Battelle prepared this document. It was reviewed by the SDDOT Project Technical Panel and comment incorporated.

The execution of this Evaluation Plan will also be a joint effort. In general, the data collection will be the responsibility of SDDOT and Iteris, Inc., and the analysis and development of the evaluation report will be the responsibility of Battelle. Specifically, the responsibilities are outlined in Table B-6 below.

Table B-6. Responsibilities during Evaluation Plan Execution

Evaluation Activity	South Dakota DOT/Iteris, Inc.			Battelle		
	Primary	Secondary	Review	Primary	Secondary	Review
Support SDDOT project team with Evaluation overview to staff participants, if needed.			●	●		
Prepare, review, and finalize maintenance staff system satisfaction log form and interview guide in support of Hyps #1 and 2.		●(1)	●	●		
Develop new system logs to support Hyps #2 and 3.	●					●
Recruit traveler participants to provide input during evaluation - Non-state DOT employees - CVOs - Other volunteers	●					●
Prepare, review and finalize Internet survey and participant surveys in support or Hyp #4.		●(3)	●	●		
Prepare, review and finalize interview guides to obtain information from other state agencies or neighboring states.		●(3)	●	●		
Collect data from system logs during evaluation period and provide to evaluation team.	●				●(2)	
Collect data from website hits and prepare statistics.	●					●
Conduct internet and participant surveys with traveler (volunteers).	●				●(4)	
Conduct interviews with other partner state agencies.	●				●(4)	
Analyze data to test hypotheses and draw conclusions.		●(5)		●		
Document results in Evaluation Report.			●	●		

Notes:

(1) Contribute input and questions for log form and interview guide development.

(2) Battelle will work closely with the Iteris development team to ensure system logs will generate needed data.

(3) Contribute input and questions for survey development.

(4) Battelle will be present during interviews, as time and budget allows.

(5) Work closely with Battelle to analyze data and provide insights into conclusions.

U.S. Department of Transportation
ITS Joint Program Office-HOIT
1200 New Jersey Avenue, SE
Washington, DC 20590

Toll-Free “Help Line” 866-367-7487
www.its.dot.gov

FHWA-JPO-16-269

U.S. Department of Transportation