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Weather Information Integration in Transportation Management Center (TMC) Operations

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14. ABSTRACT (Maximum 200 words)

This report presents the results of the third phase of an on-going FHWA study on weather integration in Transportation Management Center (TMC) operations. The report briefly describes the earlier phases of the integration study, summarizes the findings from the implementation and evaluation of an automated weather alert notification system in the Sacramento Regional TMC, and discusses the efforts of four TMCs (Cheyenne, Colorado Springs, Kansas City, Louisiana, and Redding) that used the FHWA self-evaluation guide to identify their weather integration needs and strategies that could be implemented to meet those needs. Four of those TMCs prepared weather integration plans with implementation tasks and schedules. The report tracks their progress toward implementing those strategies and identifies the outcomes and benefits they have achieved to date. Efforts to refine, market and promote the self-evaluation guide are also discussed. Finally, lessons learned and recommendations based on the experiences working with a variety of TMCs are offered to encourage and facilitate greater weather information integration in the future.

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Preface/ Acknowledgements

This report is the third in a series of linked studies, beginning in 2004, that have sought to develop and promote strategies that support Transportation Management Centers (TMCs) in more effectively and proactively responding to a variety of road weather events and conditions that impact traffic and transportation system performance. The content of this report focuses on selected TMCs, their identified needs for weather integration in operations, their selected strategies for meeting those needs, and, in one case, an evaluation of the implementation of one of those strategies – an automated weather alert notification system. The members of the consultant team and authors of this report would like to acknowledge and thank the many individuals in the Road Weather Management Program and in many TMCs around the country who have enthusiastically supported this program with their time, effort, and ideas for improving weather integration. TMC managers and operators spent significant time working through a self-evaluation and planning process, and worked collegially together to help make this program a success.

While many individuals deserve recognition, we want to particularly acknowledge a few individuals for supporting and coordinating efforts to encourage enhanced weather information integration in their TMCs. Jason Sims and Nancy Powell at Kansas City Scout, Brian Simi and Bob McNew at the Sacramento RTMC, Rob Helt and Steve Tobias at the Colorado Springs TMC, Vince Garcia and Kevin Cox at the Wyoming Statewide TMC, and Michael Muffoletto at the Shreveport, Louisiana TMC were all immensely supportive and engaged in this effort. Finally, Roemer Alfelor and Paul Pisano of the Road Weather Management Program have provided their on-going support of this effort with a clear guiding vision of how the proactive use of weather information in TMC operations can improve the performance of our nation's transportation system and the experience, safety and mobility of all travelers.

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Executive Summary

Background

The Federal Highway Administration's (FHWA) Road Weather Management Program (RWMP) has identified the integration of weather information into the operations of Transportation Management Centers (TMCs) across the country as one of its key objectives. Since early 2004, the RWMP has sponsored a series of three linked studies to develop a concept of weather integration, identify best practices being used by TMCs, and support leading TMCs as demonstration sites for effective integration of weather information in their daily operations. This report describes the third phase of this effort that has focused on the preparation of detailed weather integration implementation plans by selected TMCs, the deployment of integrated systems, and the evaluation of the performance and benefits of those systems. Weather information integration is beginning to take hold but much remains to be done to further raise awareness of the benefits of weather integration and encourage more widespread adoption of weather integration strategies. This report offers several recommendations for additional steps that will need to be taken to more fully accomplish the program objectives.

During the current phase of this weather integration project, assistance was provided to the Sacramento Regional TMC (RTMC) in implementing and evaluating a weather alert notification system based on a strategy identified in their self-evaluation. Three additional TMCs participated in the self-evaluation and integration planning process, including Kansas City Scout, Colorado Springs, Colorado, and the Louisiana statewide TMCs. This study included expanding weather integration activities with additional TMCs, supporting the development and distribution of various marketing strategies and materials, and refining the self-evaluation and planning guidelines to support greater integration in the future. The scope was expanded further to include two interested TMCs (Cheyenne, Wyoming and Redding, CA) that were willing to work with the Guide on their own, with minimal outside support, to conduct the self-evaluation and develop a plan. These efforts allowed both TMC's to identify new levels of weather integration on their own, and proved the ability of the Guide to support such efforts. In addition to these activities, a strategic marketing plan was developed to guide various promotional activities and products in support of weather integration. Finally, the self-evaluation and planning Guide was updated and refined based on the experiences working with the TMCs and their suggestions for improvement. This report describes these and all TMC weather integration activities supported by FHWA to date.

TMC Self-Evaluation, Planning and Implementation Process

Individual deployment plans were prepared in collaboration with the teams formed at each of the TMCs that selected the integration strategies and developed schedules for implementing the integration strategies. With assistance provided through periodic conference calls and several site visits to each participating TMC, their teams worked through the self-evaluation Guide to identify the priority integration strategies that were aligned with their expressed needs to improve operations using integrated weather information. Each TMC cycled through this process several times, making adjustments to their prioritized needs, in order to develop a manageable set of weather integration strategies that seemed feasible for them to implement. The next step was to prepare an integration plan that included an initial outline of the tasks they intended to implement, along with a schedule, in order to achieve the new levels of weather integration they desire. This report provides extensive details for each of these TMCs on their selected priority needs, their target levels of weather integration for each of eleven items of integration, and the specific integration tasks they selected for implementation. The activities of each TMC are noted below:

- **Sacramento, California Regional TMC:** Implemented and evaluated the performance of a weather alert notification system
- **Kansas City Scout TMC:** Integrating weather event forecast information into their Advanced Traffic Management System (ATMS)
- **Colorado Springs TMC:** Conducting a pilot study on winter weather arterial signal timing in one of their city grids
- **Louisiana statewide TMCs:** Completed a comprehensive statewide self-evaluation and integration plan across their four TMCs
- **Wyoming Statewide TMC:** Expanding road weather information sensor coverage and implementing additional variable speed limit notification system in key corridors
- **Redding, California TMC:** Completed their self-evaluation but resource limitations prevented them from completing an integration plan

Evaluation of the Sacramento Regional TMC Weather Alert Notification System

Since 2007 the Caltrans District 3 Regional Transportation Management Center (RTMC) has been participating in the FHWA weather integration study to identify, implement and evaluate strategies to improve the use of weather information in their operations. A separate report documents the full details of a weather alert notification system they developed and the results of an evaluation of this system (Report No. FHWA-JPO-10-063. NTL No. 14969).

The evaluation of the Sacramento RTMC weather alert notification system examined several adverse weather events in detail in order to assess quantitatively how the alert system was performing and how the operators were able to use it in supporting their operational decisions regarding posting of advisory messages. In assessing the RTMC operator responses to these weather events, several indicators were considered:

- Were the warnings and alerts issued appropriately and according to the designated thresholds?
- To what extent was the event covered by messaging to the public?
- Were the appropriate message signs activated based on receipt of alerts and readings from the various sensor sites?
- Were signs deactivated in an appropriate and reasonably timely way?
- Did the operators record information about the event and their decisions in the TMC log?

Key findings included the following:

- The alerts were mostly well timed, indicating the alert notification system was working as planned.
- Messaging coverage was generally good but not complete. However, coverage improved over the duration of the evaluation from December 2009 to April 2010, suggesting that the alerts were helping operators post messages more appropriately.
- A low number of primary message signs had messages posted during the weather event case studies examined, but coverage improved over the course of the evaluation period, presumably due to the operators' increasing familiarity with, and understanding of, the new procedures.
- There were a number of periods after weather events had subsided during which messages were left active longer than needed or desired. The RTMC intends to address this issue with a future system upgrade that will provide operators an alert for the end of an event.
- Operator training is essential for successful weather integration.
- Alert notification procedures need to be clearly and consistently specified.
- Time and resource constraints faced by TMCs affect the performance of an alert notification system.

Strategic Marketing of Weather Integration

As a generalization, weather integration is currently at a relatively low level in most TMCs across the country. In many TMCs it is nonexistent at this time, even though weather, in some form, is affecting transportation safety and mobility everywhere. In addition to the technical tasks that involved working with a small set of TMCs, the strategic marketing efforts focused on activities aimed at increasing the awareness and capabilities of TMCs for integrating weather information in their daily operations.

A strategic marketing plan was developed as part of this study. The plan identified the primary and secondary audiences, the key messages to be conveyed, the challenges to be overcome, and the benefits of weather information integration. The plan also contained an itemized list of activities that supported the marketing efforts. Over the course of the project, various activities were conducted based on the plan.

Overall, the marketing approach resulted in a broad dissemination of the concepts of weather information integration and shared the experiences of the various TMCs engaged in this project. Quantitative numbers are difficult to track and in some cases may be realized only at a later date. The outputs of the marketing and outreach effort identified to date include the following:

- There were over 70 downloads of the Guide following the webinar held June 10, 2010.
- Over 10 presentations were made at various conferences and stakeholder groups on the project by team members and FHWA.
- A Public Roads article published in January 2011 for managing traffic operations during adverse weather events (authored by Roemer Alfelor and David Yang of FHWA) contained a subsection on weather information integration drawing upon results of this study.
- Over 23 TMCs were contacted as part of this study to participate in self-evaluation efforts, and the final participants were selected from that initial list of contacted TMCs.

- A total of six (6) agencies have completed the self-evaluation process. All but one of them have developed integration plans.
- Four (4) TMCs (Sacramento, Kansas City, Wyoming, Colorado Springs) are starting to implement their integration plans/strategies.
- Wyoming TMC and Kansas City Scout have made presentations to other peer groups (ITS Heartland, *Clarus*/Maintenance Decision Support System (MDSS) stakeholder groups) about the benefits of weather information integration and the self-evaluation process.

Ongoing marketing activities for the weather information integration will likely have to overcome a number of challenges. These include challenges associated with TMC willingness to consider weather integration, to invest in the effort and resources required to make integration successful, and to understand and use the Guide effectively. Recognizing these challenges and preparing to overcome them will be essential to a successful marketing effort.

Refinement of the Self-Evaluation Guide

The TMC representatives who participated in this project appreciated the thoroughness of the Guide content, clarity of instructions, and the applicability of the integration strategies presented. Specific feedback was requested and obtained based on the use of the electronic version of the tool. The Guide was updated and improved based on the suggestions from the users.

Technically, the Guide needs a periodic update of the Weather Information Integration Strategies and User Needs. Currently, there are 11 items of integration and 5 levels for each item. These were developed to cover the gamut of information integration options in 2008. With improving technologies and capabilities within TMCs, these strategies need to be reviewed and updated. Similarly, the user needs should be reviewed and updated to reflect the current desires of TMCs.

Accomplishments and Lessons

The accomplishments of many of these TMCs toward the implementation of selected integration strategies are noteworthy and reflect their managements' recognition of the critical impacts of weather on their operations and a strong motivation to better position their operations to take advantage of improved access to weather information.

All these TMCs can point to a common set of important accomplishments achieved through their participation in the weather information integration study, as follows.

- Four comprehensive weather integration plans were prepared that serve not only to guide each TMC's future integration implementation efforts but also to offer clear examples for the benefit of other TMCs of weather integration across a range of strategies and under varying conditions.
- Each TMC established, through participation in the weather integration process, new partnerships, both internal and external to their agency that served to enhance their overall operations, provide benefit to the traveling public, and chart a pathway to improved working relationships in the future.

- TMCs acknowledged the importance of working closely with their counterparts in maintenance. Stronger relationships were established that will encourage collaborative activities and foster active sharing of weather information.
- Awareness was raised at all levels of the DOT organizations involved, from TMC operators and field staff to upper management, of the potential role and value of weather information to enhance the quality and content of traffic operations, and the value of a more proactive stance with regard to managing their systems before, during, and after weather events.

A review of the accomplishments achieved so far by the TMCs that have participated in the weather information integration program over the past six years illustrates a number of “success factors,” lessons, and remaining challenges based on these experiences that can be expected to be relevant to any TMC. Various lessons learned have been identified in prior reports related to this project (Report Nos. FHWA-HOP-06-090. EDL No. 14247; FHWA-JPO-08-058. EDL No. 14438; and FHWA-JPO-10-063. NTL No. 14969), and the potential value of these lessons is tied to creating a wider awareness of the benefits of weather integration and engagement in a process to identify and deploy integration strategies that can improve the operations of TMCs across the country. Broad lessons, common across each of the TMCs in this study, include the following:

- TMC managers are not generally predisposed to seek out new ways to integrate weather information into their traffic operations, and often they are unaware of weather resources that exist within their broader agency. After participating in the self-evaluation and integration planning process, the TMCs in this study recognized the potential value offered by weather integration, but for the most part required considerable assistance in moving forward to incorporate new ways to integrate weather. Self-motivation sufficient to support achievement of real changes in operations based on weather integration, along with a clear understanding of the steps they needed to take, appears to be rare.
- Resources, both financial and staff, constitute a serious challenge to the successful promotion of weather integration in TMCs. While this point has been made a number of times before, it deserves repeating. This is not just a temporary problem associated with particularly difficult economic conditions in many states. TMC personnel are so stretched to fulfill their daily obligations and tasks, that motivating them to take on a new set of tasks and responsibilities, including modifying policies and procedures to support new ways of operating with weather information, is very difficult. Although TMC managers and operators may agree that enhanced weather integration could help them better meet their operational needs and serve their traveling public, weather integration simply does not represent a high enough priority for them among their many tasks.
- While the weather integration study has focused on enhancing TMC operations, the process depends on teamwork not only within the TMC but also with other agencies and stakeholders. Many, though not all, TMCs have separate structures for their operations and maintenance components. The most effective weather integration implies a seamless sharing of information and decision making across operations and maintenance, but the historical arrangements in TMCs often present major institutional and cultural barriers that hinder information sharing. Engagement in the weather information integration project has helped overcome these barriers where they have existed, but the motivation for TMCs and State DOTs to make that happen is lacking.

Recommendations

Four recommendations are offered that focus on the need to build a sustainable weather integration program, effectively promote such a program with documented benefits, refine and maintain a comprehensive tool to evaluate weather information integration in a particular TMC, and identify the most technologically advanced strategies to enhance its capabilities.

1. **Assure Progress and Sustainability of Weather Integration**

   Objective: A goal of the RWMP is to encourage widespread awareness of the value of integrating weather information and systems into TMC operations and progress toward accomplishing that, resulting in a high degree of weather information usage in transportation operations and management.

   Approach: Long-term progress incorporating weather integration into TMC operations must be grounded in a motivated TMC constituency that understands the role of weather integration in the context of WRTM, and not allowed to remain dependent on continued outside assistance. This can be achieved by a multi-pronged strategy that includes the following elements:

   - Follow-up actively on the marketing strategies identified in the current program.
   - Continue to emphasize weather integration as a key component of WRTM.
   - Develop and actively support an institutional strategy within the RWMP to respond to TMC questions and needs with regard to weather integration, including training and networking support.
   - Sponsor one or more workshops with representation from all stakeholders (TMC operations and maintenance; emergency management agencies; software developers; meteorologists; etc.). Include leading weather integrators who can speak from successes.
   - Work closely with and provide support to organizations or groups that include members of the TMC community or work with TMCs, such as the TMC Pooled Fund Program, the TRB, the Institute of Transportation Engineers (ITE), and the American Association of State Highway and Transportation Officials (AASHTO) and their committees and subcommittees that focus on operations and maintenance. Make presentations to these groups based on successful weather integration experiences, encourage them to focus on weather integration, and make them a part of an institutional strategy for sustainable support of weather integration.
   - In the short run, actively support TMCs that express an interest in weather integration, but seek to replace such *ad hoc* responses with an institutionalized, sustainable support infrastructure.
   - Engage each of the major new transportation initiatives to educate and promote with regard to weather integration and include their representatives in the new institutional mechanisms.
   - Seek to overcome the traditional separation and communication barriers between TMC operations and maintenance.

Outcome: The outcome of this recommended set of activities would be a rapid increase of the number of TMCs that undertake weather integration activities in their operations and a growth in sophistication among TMCs that have already made some headway toward weather integration. Weather integration should become mostly self-supporting and no longer require on-going costly outside support in order to motivate adoption.

2. **Identify and Document Evidence of Weather Integration Benefits**

Objective: In order to successfully promote the weather information integration initiative and encourage TMCs to consider weather integration strategies to improve their operations, they need to better understand the potential benefits of implementing these strategies.

Approach: Continue to support Kansas City Scout TMC to finalize and implement their evaluation plan. Continue working with the Wyoming Statewide TMC to complete their integration plan implementation, prepare an evaluation plan, and evaluate their implementation. Continue to work with the Colorado Springs TMC to complete the pilot test of their weather responsive signal timing plans, develop a plan to evaluate the performance of that test, and evaluate the test as a basis for considering expansion throughout their system. Investigate other TMCs that may be enhancing their weather information integration capability (including those that downloaded the Guide and those that are known to be improving their capabilities), prepare a short list of those that are actively implementing a weather integration strategy, and assist them to evaluate their strategy implementation.

Outcome: The outcome of this recommendation will be a set of documented benefits (a report and database) attributable to the implementation of specific weather information integration strategies that could be used to promote and sustain the RWMP's weather integration in traffic operations initiative.

3. **Assure Currency and Relevance of Weather Integration**

Objective: In order to encourage and assure the adoption of weather information integration strategies in TMC operations, the RWMP must facilitate the on-going evolution of integration strategies to "keep pace" with rapid technology and programmatic developments of direct interest to TMC traffic operations and management.

Approach: Prepare a white paper on "Relevance of Weather Information Integration to TMCs" that would:

- Describe advances in ATMS hardware and software that can accept and support improved processing and management of weather information.
- Identify and describe the major current transportation program initiatives and how weather information serves as inputs to those programs along with how the programs can encourage and benefit weather integration strategies. The role of weather information integration needs to be examined in three major emerging programs – Active Transportation Demand Management (ATDM), Integrated Corridor Management (ICM), and the Connected Vehicle initiative. In each of these programs, RWMP should encourage increased understanding and use of weather information. For example, future ICM initiatives around the country should consider a weather-responsive scenario and the ATDM program could focus on linking active traffic management & travel demand management during adverse weather. The RWMP

has already started engaging the Connected Vehicle community in considering vehicles not only as mobile observation platforms but also as receivers of customized spot-specific road weather information.

- The white paper should clarify in practical terms, using real examples, what it means to be proactive with regard to weather integration and how being more proactive offers benefits.

Outcome: This recommendation emphasizes the importance of staying flexible and adjusting weather information integration strategies and rationale to keep current and relevant. Outcomes would include clear, practical examples of how weather integration fits in with the current and projected major transportation program initiatives. The recommended white paper will support further marketing and promotion of weather integration among TMCs by further clarifying its operational benefits.

4. Refine Self-Evaluation Process and Improve Tool

Objective: In order for TMCs to evaluate their current and future potential level of weather integration, they require a tool that is both easy to use and is up-to-date with the most current advances in weather integration strategies.

Approach: Refine and update the weather integration self-evaluation and planning process, improving the tool's usability, and incorporating the most current technological advances in both (the process and the tool). Specifically:

- Review and update the need statements to be more reflective of TMC desires to be more proactive with their responses to road weather conditions.
- Research and update the road weather integration strategies to reflect the most advanced practices being promoted by USDOT and implemented by state DOTs and TMCs. These incorporate the latest communication, programmatic and technological advances, reflect today's best practices, and support new program initiatives such as Connected Vehicles, ICM and ATDM.
- Improve the matrix of needs for weather integration strategies based on the findings of the first two bullets.
- Revise and host the tool on a new and more flexible platform (an Internet-based product).

Outcome: The outcome of this recommendation will be a technically and programmatically current weather integration self-evaluation and planning process, and an easier tool that TMCs can use to investigate and implement possible road weather integration strategies to improve their operations during inclement weather conditions.

Conclusion

This report has demonstrated significant progress towards implementation of advanced levels of weather information integration strategies among many of the TMCs that participated in this study. They have important accomplishments to show for their efforts. The future holds great opportunity to extend the benefits of weather integration to many more TMCs across the country that face weather challenges in their daily traffic operations. This study presented some lessons from the experience of the past six years of the FHWA Road Weather program that highlight the importance of strong self-motivation within TMCs to engage a team composed of operations, maintenance and related agency representatives in weather integration within an environment of constrained resources. The four recommendations presented are directed toward sustaining and enhancing the weather integration program, building additional evidence supporting the benefits of integration, and assuring that the support and tools available to TMCs to help them are effective and up-to-date.

1.0 Introduction and Background

The Federal Highway Administration's (FHWA) Road Weather Management Program (RWMP) has identified the integration of weather information into the operations of Transportation Management Centers (TMCs) across the country as a key objective. Since early 2004, the RWMP has sponsored a series of three linked studies to develop a concept of weather integration, identify best practices being used by TMCs, and support leading TMCs as demonstration sites for effective integration of weather information in their daily operations. This report describes the third phase of this effort that has focused on the preparation of detailed weather integration implementation plans by selected TMCs, the deployment of integrated systems, and the evaluation of the performance and benefits of those systems. Weather information integration is beginning to take hold but much remains to be done to further raise awareness of the benefits of weather integration and encourage more widespread adoption of weather integration strategies. This report offers several recommendations for additional steps that will need to be taken to more fully accomplish the program objectives.

1.1 Project History

Phase I Integration Study: 2004-2005. The first study in the weather integration series began with an investigation of the needs and opportunities for the integration of emergency and weather elements in TMC operations, along with an exploration of the concepts, methods and potential benefits of integration to improve operations. Thirty eight TMCs across the country were contacted, and ten of them were visited. These TMCs demonstrated current best practices in the integration of weather and emergency information and systems. The final report from this study[1] summarized how weather and emergency information and decision-support systems were being integrated in these TMCs. In order to better organize and present the activities of these TMCs, further background research was conducted to help define and clarify the concept of integration. Potential benefits of integration were identified, including the following:

- Improved access to all regional information using compatible, standards-based systems over reliable communication systems.
- Ability to coordinate and pool resources to accomplish operations not currently possible.
- Improved clarity of roles and ability to communicate both current operations and future investments.
- More timely and accurate information provided to the traveling public, thereby increasing customer safety and satisfaction.
- Better prepared TMC operators to address adverse weather on the transportation system in terms of appropriate staffing and implementation of traffic advisories and control strategies.

[1] Cluett, C., Kitchener, F., Shank, D., Osborne, L., and Conger, S. (2006). *Integration of Emergency and Weather Elements into Transportation Management Centers* (Report No. FHWA-HOP-06-090. EDL No. 14247). Washington, DC: Federal Highway Administration. Available at: http://ntl.bts.gov/lib/jpodocs/repts_te/14247_files/14247.pdf

Nine recommendations were offered to help encourage and enhance weather integration. These included enhancing awareness of the value of weather information integration, promoting the concept and best practices, self-evaluation of integration needs, developing integration guidelines, improving communication between the weather and transportation communities, fostering research on how weather integration can help TMC operations, and encouraging uniform practices of integration across TMCs.

Phase II Integration Study: 2006-2008. The second study[2] in the weather integration series built upon the recommendation from the first study that TMCs "should conduct a self-evaluation to help identify the most effective integration solutions and guide their deployment." A self-evaluation guide was developed, using Microsoft Access, to assist TMCs in identifying their weather integration needs and matching their high priority needs with appropriate, implementable integration strategies. Also included was an outline for preparing a comprehensive integration plan. This study was centered on two TMCs (Sacramento, CA and Milwaukee, WI) that formed multi-agency teams to identify practical, implementable weather information integration strategies. Based on the experiences of these TMCs, lessons learned were presented, and suggestions for improving the Guide were incorporated into an updated version that was made publically available on the RWMP website.

Eleven recommendations were offered, based on the experience working with these TMCs, primarily related to education and training, and further implementation and refinement of the self-evaluation process supported by the Guide. Underlying these recommendations are a few common themes that include the need for:

- key individuals in the state Departments of Transportation (DOTs) and TMCs to champion weather integration,
- motivation to engage in a partnership among DOT management, TMC operations and maintenance, representatives of related agencies (e.g., emergency response, highway patrol), and the meteorological community,
- an evidence base that demonstrates the benefit-cost advantages of integration, with evaluation and promotion of the value of integration based on that evidence, and
- resources (staff, money and materials) to fully support weather integration implementation.

Phase III Integration Study: 2009-2011. The third study in the weather integration series is the subject of this report. During this latest period, the consultant team assisted the Sacramento Regional TMC (RTMC) in carrying out and evaluating a weather alert notification system that they had implemented, based on a strategy identified in their self-evaluation. Three additional TMCs volunteered to participate in the self-evaluation and integration planning process, including Kansas City Scout, Colorado Springs, Colorado, and the Louisiana State TMCs. The scope of this phase of the study included expanding weather integration activities with additional TMCs, supporting the development and distribution of various marketing strategies and materials, and refining the self-evaluation and planning guidelines to support greater integration in the future. After this phase was underway, the scope was expanded further to include two interested TMCs that were willing to work with the Guide on their own,

[2] Cluett, C., Gopalakrishna, D., Balke, K., Kitchener, F., and Osborne, L. (2008). *Integrating Weather in TMC Operations.* (Report No. FHWA-JPO-08-058. EDL No. 14438). Washington, DC: Federal Highway Administration. Available at: http://ntl.bts.gov/lib/30000/30900/30940/tmc_wx_integration_report_11_17_08.pdf

with minimal outside support, to conduct their self-evaluation and develop a plan. This served as a test of the ability of the Wyoming Statewide TMC and the Redding, California TMC to achieve new levels of weather integration on their own and the ability of the Guide to support those efforts. This report describes the conduct and results of this third phase study.

1.2 Policy Background for Weather Information Integration

Prior to the first phase of the weather information integration studies, the FHWA sponsored a study to develop a concept of operations for managing weather events.[3] This concept is grounded in three basic operational objectives: maintain and improve safety, maintain and improve mobility, and improve agency productivity. According to the study, to achieve these objectives with regard to operating under adverse weather conditions, a transportation agency gathers information and seeks to predict or anticipate potential impacts, and employs mitigation strategies either in anticipation or in response to impacts. The report concludes that, while weather-responsive traffic operations offers great value to managers, "this concept will be enhanced by [the] establishment of mechanisms for improved coordination within transportation agency divisions and between transportation agencies and other key response agencies (p. 4-1)." Right after this study, the National Academy of Science conducted a study that has served to guide the RWMP in framing its research agenda. This study recognized the importance of inter-agency coordination in support of weather integration and provided recommendations for research to "provide a framework to engage the transportation and weather communities [to help them] capitalize on existing capabilities and take advantage of opportunities for advances (p. 2)."[4]

Recognizing the unacceptably high safety and mobility impacts of severe weather on the transportation system, the RWMP established a roadmap of programmatic initiatives in an effort to help state DOTs and affiliated agencies mitigate the adverse effects of weather. One of those important initiatives has included the weather information integration studies. The RWMP created a framework for its Weather Responsive Traffic Management (WRTM) program that illustrates how weather information integration dovetails with the other key elements in the program (Figure 1).

The starting point for the weather integration project was to identify TMCs engaged in best practices with regard to taking weather into account in their operational decision-making and build from that base to encourage more TMCs to adopt weather integration strategies. Further work has clarified both the potential benefits of integration and the challenges faced in achieving that goal. A common thread throughout this work is the recognition of the success factors of having a combination of an informed and motivated operational team along with the identification of clear integration strategies and the resources to support their implementation.

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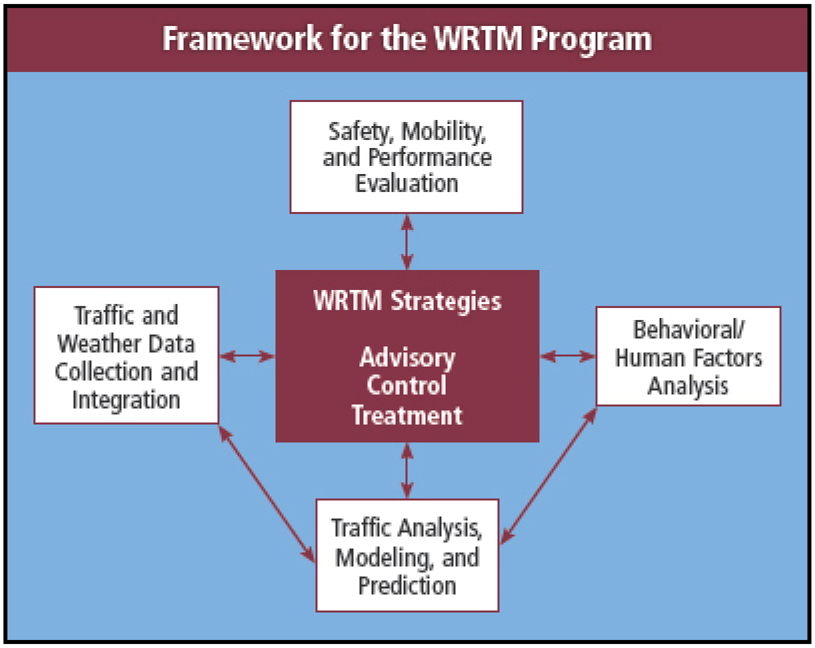
[3] Federal Highway Administration. 2003. *Weather-Responsive Traffic Management: Concept of Operations.* Draft report prepared by Cambridge Systematics, Inc. (January 10).
[4] National Research Council of the National Academies, Committee on Weather Research for Surface Transportation: The Roadway Environment. 2004. *Where the Weather Meets the Road: A Research Agenda for Improving Road Weather Services.* Washington, D.C.: The National Academies Press.

Figure 1. Framework for the WRTM Program



Source: FHWA

Based on the experience to date, successful strategies have been identified and deployed, but much more needs to be done to extend the benefits of weather information integration to a significant number of TMCs in the country. Effective integration of weather information and services into TMCs will facilitate and support:

- Well-informed maintenance and operational staff who understand the effects of weather events on road conditions and transportation system performance, along with the value of a coordinated road weather management system.
- Timely and more pro-active operational decision making, including the ability to effectively respond to forecast weather events and prepare before serious problems arise.
- Operational understanding of available weather integration tools and how to use them effectively in a TMC.
- The value of a weather perspective embedded in the TMC concept of operations and accepted by management as the preferred way of conducting the functions of the TMC.
- A weather responsive performance assessment system that monitors TMC performance and supports a continuous improvement process.

1.3 Contents of this Report

This report discusses the activities conducted as part of Phase III of the weather information integration study. The following sections are covered:

- Section 3.0: Describes the selection criteria and process followed to identify prospective TMCs to participate in self-evaluation of weather integration needs and the development of an integration plan based on identified integration strategies. The TMCs were divided into two tiers, Tier 1 receiving extensive support in working with the Guide and Tier 2 agreeing to work mostly on their own.

- Section 4.0: Describes the planning process at the Tier 1 and Tier 2 sites.
- Section 5.0: Describes the implementation and evaluation of a weather alert notification system at the Sacramento RTMC.
- Section 6.0: Describes a strategic marketing plan and measures of integration performance.
- Section 7.0: Describes modifications to the Self-Evaluation and Integration Planning Guide that were made, based on experiences working with various TMCs and the feedback they provided for Guide improvement.
- Section 8.0: Describes the overall accomplishments of the weather integration work, including the lessons learned.
- Section 9.0: Provides four recommendations for further program consideration based on the cumulative experiences of the past seven years of weather integration work.

2.0 Identifying Candidate TMCs for Weather Information Integration

This section describes the process to select TMCs for participation, the TMCs selected, and the specific plans developed for each TMC to conduct the self-evaluation. The selection and planning processes were carried out to:

1. Identify criteria by which TMC's would be evaluated and selected for project participation
2. Identify candidate TMC's and recommend a limited number to participate
3. Define a project deployment plan for following up with each TMC selected

The deployment plan was completed in April 2009 as an internal project document. It contained a list of all TMCs contacted and their levels of interest in weather information integration.

Five TMC candidates were selected because it was felt they would significantly benefit from enhancing weather information integration in their operations and were interested and motivated to participate. These candidate TMCs were grouped into two tiers and received different levels of assistance from the consultant team to work through the Guide and develop a weather integration plan.

The five selected TMCs are a good representation of TMCs across the country with varied geographic locations, types of operations, and weather conditions that impact their respective transportation systems. Also, the TMCs varied in their current levels of weather integration and therefore offered good opportunities to identify and evaluate different integration strategies.

2.1 TMC Site Selection Process

The goal of the selection process was to identify TMCs that the consultant team could support to 1) conduct a self-evaluation that is responsive to their needs and results in weather integration strategies suitable for deployment, and 2) prepare a weather integration plan.

2.1.1 Selection Criteria

Selecting the most appropriate TMCs was essential to the success of the project. The consultant team established and used the following criteria to screen a long list of potential TMCs and select those that would receive assistance to work through the Guide and develop an integration plan.

A. **Region** – a balanced representation of TMCs across the country
B. **Operations** – variety of operational types with at least one focused on arterial management
C. **Weather impacting transportation system** – variety of weather types
D. **Level of weather impacts on transportation system** – significant weather impacts

E. **Current level of availability and use of weather information in operations** – range from low to high to reflect the circumstances of TMCs across the country
F. **Interest in integrating weather information into TMC operations** – strong interest in enhancing their level of weather integration
G. **Potential to be national case study example of weather information integration** – high potential to serve as a national example
H. **Extent of institutional and/or technological barriers** – indication of low barriers to weather integration
I. **Willingness to participate in the project** – Strong willingness to participate

It was important that a TMC indicated a strong interest in participating in the process; however, the focus was on identifying TMCs that could demonstrate the benefits of integration and were diverse in the types of weather integration they sought and the weather and operational characteristics of their TMC location in order to enhance the potential marketing insights and benefits. Additionally, diverse types of transportation operations were also important, with the goal of including at least one TMC that managed an arterial network. Table 1 summarizes the selection criteria and defines the anticipated variation in each of the criteria and desired outcome for each of the TMCs. Recognizing that it would be difficult to find TMCs that are ideal with respect to every criterion, the selection process sought to identify TMCs that most closely met the project goals.

Table 1. TMC Weather Integration Assessment, Plan Development and Implementation Selection Criteria

A	B	C	D	E	F	G	H	I
Region	Operations	Weather impacting transportation system	Level of weather impacts on transportation system	Current level of availability and use of Wx information in operations	Interest in integrating Wx information into TMC Operations	Potential to be national case study example of weather information integration	Extent of institutional and/or technological barriers	Willingness to participate in the project
Anticipated variation in each of the criteria								
West, North, South, East, Northwest, Southwest, Northeast, Southeast, North central, South central.	Regional or statewide. Freeway, arterial or both. Urban or rural	Snow, ice, freezing rain, heavy rain, flooding, hurricanes, blowing dust/sand, blizzards.	High, Medium, or Low. Judgment of interviewer based on response to questions.	High, Medium, or Low. Judgment of interviewer based on response to questions derived from the integration matrix.	Strong, mild, or no interest. Types of improvements that they are interested in and expected benefits.	High, Medium, or Low. Judgment of interviewer based on response to questions.	High, Medium, or Low. Judgment of interviewer based on response to questions.	Willing or not willing.
Desired outcome of TMC selection process								
Regional balance	Variety of operational types. At least one focused on managing arterials	Variety of weather types	Significant (high) weather impacts	Mix of low to high use levels for Wx information	Strong interest in enhancing Wx integration; variation in desired types of Wx integration	High potential to serve as national example	Low barriers to Wx integration	Strong willingness to participate in self-assessment and plan development.

2.1.2 Identifying Candidate TMCs

The process to identify candidate TMCs began with the development of a list of potential candidates, considering the selection criteria described above and the following components:

- Review of previous TMC lists from the earlier phases of the weather integration studies. Some TMCs were eliminated and others were carried forward based on how well they met the criteria.
- Input from FHWA and the consultant team regarding their experience and knowledge of TMCs and their operations.
- Interest expressed by TMC Pooled Fund members during a presentation to this group in Nashville, TN on July 15, 2008. Some members who represent member states said they were interested in further discussions and were subsequently contacted. They suggested several TMCs in their states that were added to the list.
- Response to the 2007 Intelligent Transportation System (ITS) Infrastructure TMC Survey[5]. Several appeared to be good candidates and were added to the list.

This resulted in a list of thirty-nine potential TMCs. Of the original thirty-nine, the consultant team discussed the potential project participation with personnel from twenty-three TMCs. Once enough TMCs were identified, the consultant team stopped contacting TMCs.

The consultant team contacted the TMCs by phone to learn more about their operations and interest level, asking a set of questions based on each of the selection criteria to determine their suitability for participation. The results of these discussions and recommendations of TMCs to work through the self-evaluation and integration planning processes are presented in the next section.

2.1.3 Selection of the Most Promising TMCs

Based on the responses during the phone interviews, the TMCs were categorized as follows:

- Four TMCs indicated that they did not require the use of weather information and therefore were not interested in participating. This may have been because weather did not play a significant role in traffic management challenges faced by the TMC or that weather information was handled by another organization (such as maintenance) and the TMC did not perceive a need for the information.
- Five TMCs indicated that their operations did require the use of weather information, but they felt they had what they needed and were not planning to enhance their weather integration capabilities.
- Five TMCs expressed an interest in enhancing their current level of weather integration, but felt they could not devote the time and resources required to participate in the project at this time.
- Four TMCs were interested in participating, but after discussing their operations with the consultant team it was apparent that they did not sufficiently meet the selection criteria.
- Five TMCs expressed a high level of interest in enhancing their level of weather integration in their operations. Based on the interviews, the consultant team determined they best fit the selection criteria.

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[5] Research and Innovative Technology Administration. (2007). *ITS Deployment Statistics Database: Survey and Results.* Washington, DC: U.S. Department of Transportation. Available at: www.itsdeployment.its.dot.gov.

These five TMCs, along with their strong interest, exhibited the right conditions to benefit from enhanced weather integration. Additional phone conversations were conducted with these TMCs to learn more about the possibilities of their involvement and to ensure their full commitment to the self-evaluation process and development of an integration plan centered around their selected weather integration strategies (from the Guide).

This project was scoped to originally identify and work with three TMCs (Tier 1). In order to be responsive to the interests of the remaining qualified TMCs, the consultant team, in consultation with FHWA, recommended adding a second group (Tier 2) of TMCs to the project. These two tiers are defined as follows:

Tier 1: Three TMC will receive assistance from the consultant team as defined by the original project scope, including 3-4 visits to their location to work through the self-evaluation and develop an Integration Plan.

Tier 2: Up to three additional TMCs will be provided a copy of the Guide and general instructions to get started with limited assistance from the consultant team in the way of phone conversations to answer questions. No on-site visits will be planned.

The Tier 2 concept was new to the project, and offered an opportunity to determine whether TMCs can be expected to seek out the Guide on-line and successfully carry out a self-evaluation and planning process essentially on their own and without assistance. These Tier 2 TMCs would also serve as alternates to the Tier 1 group should an event arise that would prevent one of them from completing the project, and the opportunity to expose more TMCs to the Guide and obtain further input regarding its usefulness.

Table 2 identifies the five TMCs selected for project participation and their responses to each of the selection criteria.

The three TMCs recommended for Tier 1 involvement and a brief explanation of their site characteristics are as follows:

Colorado Springs Regional TMC – This TMC manages both the freeway system and arterial network for the regional area surrounding Colorado Springs, Colorado. This includes 562 signals. It experiences heavy winter snow and ice conditions, severe thunderstorms with heavy rains, dense fog, and potential for flooding. It currently exhibits a low level of weather integration and is very interested in enhancing its capabilities in this area. The TMC possesses the potential to explore weather integration strategies to better manage traffic flow on arterials during winter storm conditions with revised signal timing plans. This site offers an opportunity to show how smaller regional TMCs can benefit from enhanced weather integration strategies.

Table 2. Five Selected TMCs and their Responses to the Selection Criteria

TMC	Region	Type of operation	Weather impacting transportation system	Level of weather impacts on transportation system	Current level of availability and use of weather information on operations	Interest in integrating weather information into TMC operations	Potential to be national case study example of weather information integration	Extent of institutional and/or technological barriers	Willing-ness to participate in the project	Comments
TMCs RECOMMENDED FOR TIER 1 PROCESS										
Colorado Springs, CO	West Central	Regional, mostly urban, freeway/ arterials	Snow, ice, heavy rain, flooding, and fog	Medium/High	Low	Strong – want to know about what's possible. Potential for signal system application	High – regional freeway and arterial managemen;. Signal control functions with Wx. Info. Winter Wx.	Low	Willing	Potential to demonstrate proactive control of arterial signals and modification of timing patterns during winter storm events. Also, a relatively small TMC that can serve as a good example for many smaller systems around the country
Kansas City, KS	Central	Multi-state, urban, freeway	Rain, flooding, tornadoes, high winds, some snow	High	Medium	Strong – need better prediction capabilities	High – integration of weather information across two states in one TMC. All freeway, mostly advisory functions.	Low	Willing	Potential to demonstrate weather integration in TMC operations of an extensive Interstate system across a large metropolitan area involving a two-state coalition.

Table 2. Five Selected TMCs and their Responses to the Selection Criteria (continued)

TMC	Region	Type of operation	Weather impacting transportation system	Level of weather impacts on transportation system	Current level of availability and use of Weather information on operations	Interest in integrating weather information into TMC operations	Potential to be national case study example of weather information integration	Extent of institutional and/or technologic al barriers	Willing-ness to participate in the project	Comments
Louisiana – 3 regional TMCs in Shreveport, Baton Rouge, and New Orleans; and another statewide TMC located in Baton Rouge.	South	Regional and statewide, freeways	Heavy rain, flooding, hurricane, tornadoes	Medium to High	Low	Strong – Need better prediction capability and location specifics. Need better preparation details and timing.	High – Integration of weather information across four TMCs encompassin g the entire state. Mostly advisory functions, but some control related to evacuations.	Low	Willing	Potential to demonstrate integration of weather information among four separate TMCs across the state of Louisiana. Also, potential to address unique weather impacts due to tornadoes and hurricanes that may be of interest to other southern states.
TMCs RECOMMENDED FOR TIER 2 PROCESS										
Redding, CA	West	Large District, rural, freeway	Heavy rain, snow, fires, strong wind	High	Low	Strong – need for reliable forecasting	High – mountainous road conds with severe weather. Chain rqmts is primary control function.	Medium	Willing	Potential to demonstrate improved traveler information and safety warnings within a large rural region that experiences varied weather conditions.

Table 2. Five Selected TMCs and their Responses to the Selection Criteria (continued)

TMC	Region	Type of operation	Weather impacting transportation system	Level of weather impacts on transportation system	Current level of availability and use of Weather information on operations	Interest in integrating weather information into TMC operations	Potential to be national case study example of weather information integration	Extent of institutional and/or technologic al barriers	Willing-ness to participate in the project	Comments
Wyoming DOT	West	Statewide, rural, freeway	Snow, ice, strong winds, blowing snow	High	Medium	High – extremely rural, statewide center, severe winter weather	High – want to integrate weather info with new variable speed signs (control)	Low	Willing	Potential to demonstrate improved management of a statewide network of rural Interstates and state highways that experience extreme winter weather conditions, frequent road closures and strong winds.

Kansas City Scout Regional TMC – This TMC manages 125 miles of Interstate highways in the Kansas City metropolitan area across a two-state region. The TMC is jointly managed by Missouri and Kansas and is staffed by representatives from both states, with a management structure that alleviates institutional barriers that may otherwise be present. The area experiences heavy rain, flooding, tornadoes, high winds, and snow. The TMC exhibited a medium level of weather integration and was very interested in enhancing its capabilities in this area. It represents a large metropolitan area with numerous Interstate highways that experience heavy congestion and increased traffic crashes during severe weather conditions.

Louisiana Regional and Statewide TMCs – The state of Louisiana has four TMCs – three regional TMCs in Shreveport, Baton Rouge, and New Orleans (operational in Sept 2009); and a statewide TMC located in Baton Rouge. They experience heavy rain, flooding, hurricanes, and tornadoes. Although their use of weather information was expanding and their evacuation preparations had improved significantly since hurricane Katrina, they were at a relatively low level of weather integration. They were very interested in enhancing their weather integration capabilities. They represent an entire state with multiple TMCs with the potential to integrate weather in each TMC as well as between the TMCs and at a statewide level.

The two additional TMCs recommended for Tier 2 involvement and a brief explanation of their conditions are as follows:

Redding, California Caltrans District 2 TMC – This Caltrans District-wide TMC located in Redding, California (north central) manages all the California state highways and Interstates in a large seven county area. The area experiences heavy rain, flooding, snow at the higher elevations, fires, and high winds. They exhibited a low level of weather integration and were very interested in enhancing their weather operations capabilities. They represent a large geographic rural area with numerous state highways and Interstates that experience a variety of severe weather conditions that affect the highways and the safety of the traveling public.

Wyoming Statewide TMC – The state of Wyoming has one TMC in Cheyenne that manages the Interstates and all state highways that include the majority of the transportation network throughout this rural state. They primarily experience heavy snow, high winds, and blowing/drifting snow throughout the state. Interstate 80 is a major commercial goods transport corridor that traverses the lower portion of the state. The TMC exists primarily to address severe weather conditions that frequently require closure of important Interstates and state highways throughout the state during the winter months. They demonstrated a medium level of weather integration and were very interested in enhancing their weather integration capabilities. They represent a rural statewide TMC with severe weather conditions that significantly impact travel within the state.

2.2 Deployment Plans for Selected TMCs

The three recommended Tier 1 TMCs received extensive support from the consultant team as they implemented the self-evaluation and integration planning process. The two Tier 2 sites went through the same process mostly on their own, with a reduced level of interaction with the consultant team. During this process, the consultant team's objectives were as follows:

- Assist both the Tier 1 and Tier 2 TMCs to increase their level of understanding of the use of road weather information and how it can be better integrated with TMC operations.

- Assist both the Tier 1 and Tier 2 TMCs to gain a complete understanding of the Weather Integration Self-Evaluation and Planning Guide and how it can be used to identify possible strategies to enhance weather integration.
- Identify Tier 1 and Tier 2 TMCs that would be willing to promote the use of the Guide with their counterparts at other TMCs across the country and speak about their experiences and expectations for future benefits.
- Working closely with the Tier 1 TMCs, provide assistance in carrying out their self-evaluation, identifying weather integration strategies, and developing an Integration Plan.
- Provide limited assistance to the Tier 2 TMCs and track their progress with the Guide to determine what is needed for a TMC to use the Guide on their own, without extensive help from external sources.
- Derive feedback from the TMCs about possible future enhancements to improve the content and usefulness of the Guide based on the experience of both the Tier 1 and Tier 2 TMCs working with the Guide.

2.2.1 Tier 1 TMCs

The consultant team worked closely with each of the Tier 1 TMCs to work through the self-evaluation Guide, identify weather integration strategies, and develop an Integration Plan. As part of this assistance, the consultant conducted up to four site visits to provide structured support to the TMCs, as follows:

- Site visit #1: Introduce the process and the Self-Evaluation Guide and review each step and the data needed to conduct the self-evaluation. Identify the right mix of TMC staff to work through the Guide. Identify a schedule for completing the self-evaluation and plan development.
- Site visit #2: Review the results of the self-evaluation and the candidate weather integration strategies resulting from the self-evaluation. Review the Weather Integration Plan outline, and identify all the needed information to complete the Integration Plan.
- Site visit #3: Review the draft Weather Integration Plan prepared by the TMC and support the completion of the Plan.
- Site visit #4: (optional): Review the final Weather Integration Plan and discuss other input and feedback to improve the Guide and the explanation of the process. Depending on the progress made by the TMC, this final site visit may not be needed, and its activities would be incorporated into the third visit.

In addition to these site visits, the consultant conducted monthly (or as needed) phone discussions with the TMC lead contact to review progress, answer questions, and provide assistance to ensure the TMC maintained focus on the tasks and adhered to the agreed upon schedule.

Specific deployment plans were prepared and focused on each TMC that defined the activities to be conducted as part of the project tasks. Table 3, Table 4 and Table 5 provide the deployment plans. Some schedule alterations were made to ensure a smooth project implementation.

Table 3. Weather Information Integration Deployment Plan Overview: Colorado Springs, Colorado

Tier 1 TMC	Colorado Springs Regional TMC
General Description: This regional TMC manages both the freeway system and arterial network for the area surrounding Colorado Springs, Colorado. This includes 30 miles of Interstate 25 and 564 signals. They experience heavy snow and ice conditions, severe thunderstorms with heavy rains, dense fog, and potential for flooding. They currently exhibit a low level of weather integration and are very interested in enhancing their capabilities in this area.	
Primary Contact: Rob Helt, TMC Manager	**Phone:** 719-385-7603 **Email:** rhelt@springsgov.com
Others Involved: CDOT representatives from Golden, CO office; Colorado Springs Street Maintenance personnel; city Emergency Operations Center (EOC)	

Planned Activities and Tentative Schedule

Activities	Preliminary Dates
Visit 1: Kickoff and introduction meeting	4/22/09
TMC builds internal team	5/1/09
TMC completes self-evaluation and identifies Wx integration strategies	6/12/09
Visit 2: Review strategies and discuss integration planning process	6/24/09
TMC team finalizes strategies	6/26/09
TMC team prepares draft of Integration Plan	8/21/09
Visit 3: Review draft Integration Plan	8/26/09
TMC team finalizes Integration Plan	9/15/09
Visit 4 (optional): Review final Integration Plan	9/15/09
TMC completes Integration Plan; provides feedback on use of Guide	9/25/09

Project Approach/Weather Integration Opportunities:

The Colorado Springs Regional TMC will work with representatives from CDOT and the city Street Maintenance Division to conduct the self-evaluation and develop an Integration Plan. They will explore weather integration strategies to better manage their traffic flow on arterials during winter storm conditions with revised signal timing plans. They represent the opportunity to show how smaller TMCs can benefit from enhanced weather integration.

The Consultant's Planned Involvement:

The consultant team will work through the Guide with the Colorado Springs Regional TMC to help them develop their Integration Plan. Three or four visits to Colorado Springs to discuss progress and provide advice will be conducted during the course of the project. Advice may include technical information and examples from other TMCs about specific weather integration strategies that are of interest to Colorado Springs.

Table 4. Weather Information Integration Deployment Plan Overview: Kansas City, Missouri

Tier 1 TMC	**Kansas City Scout Regional TMC**
General Description: This TMC manages 125 miles of Interstate highways in the Kansas City metropolitan area across a two-state region. The TMC is jointly managed by Missouri and Kansas and is staffed by representatives from both states, with a management structure that alleviates institutional barriers that may otherwise be present. The area experiences heavy rain, flooding, tornadoes, high winds, and some snow. They currently exhibit a medium level of weather integration and are very interested in enhancing their capabilities in this area. They represent a large metropolitan area with numerous Interstate highways that experience heavy congestion and increased traffic crashes during severe weather conditions.	
Primary Contact:	**Phone:** 816-622-0528 (cell)
Jason Sims, TMC Manager	**Email:** Ervin.sims@modot.mo.gov
Others Involved: Nancy Powell – 816-347-2285	
Planned Activities and Tentative Schedule	
Activities	**Preliminary Dates**
Visit 1: Kickoff and introduction meeting	5/27/09
TMC builds internal team	5/29/09
TMC completes self-evaluation and identifies Wx integration strategies	6/26/09
Visit 2: Review strategies and discuss integration planning process	7/8/09
TMC team finalizes strategies	7/10/09
TMC team prepares draft of Integration Plan	8/28/09
Visit 3: Review draft Integration Plan	9/2/09
TMC team finalizes Integration Plan	9/15/09
Visit 4 (optional): Review final Integration Plan	9/16/09
TMC completes Integration Plan; provides feedback on use of Guide	9/25/09
Project Approach/Weather Integration Opportunities: Nancy Powell will lead a group from the Kansas City Scout TMC that will conduct the self-evaluation using the Guide and develop an integration plan. An opportunity exists to enhance their capability to display pertinent weather information on their Advanced Traffic Management System (ATMS) screens and regional maps.	
The Consultant's Planned Involvement: The consultant team will work through the Guide with the Kansas City Scout TMC to help them develop their weather integration plan. Three or four visits to Kansas City, MO to discuss progress and provide advice will be conducted during the course of the project. Advice may include technical information and examples from other TMCs about specific weather integration strategies that are of interest to Kansas City Scout.	

Table 5. Weather Information Integration Deployment Plan Overview: Louisiana

<table>
<tr><th>Tier 1 TMC</th><th colspan="2">Louisiana State TMCs</th></tr>
<tr><td colspan="3">General Description:
The state of Louisiana has four TMCs – 3 regional TMCs in Shreveport, Baton Rouge, and New Orleans (to be operational in July 2009); and a statewide TMC located in Baton Rouge. They experience heavy rain, flooding, hurricanes, and tornadoes. Although their use of weather information is expanding and their evacuation preparations have improved significantly since hurricane Katrina, they are currently judged to be at a low level of weather integration.</td></tr>
<tr><td colspan="2">Primary Contact:
Michael Muffoletto (Shreveport TMC)</td><td>Phone: 318-549-8347
Email: michaelmuffoletto@ladotd.gov</td></tr>
<tr><td colspan="3">Others Involved:
Adam Moncivaez (Statewide TMC) – 225-379-2563; Bryan Costello (Baton Rouge TMC) – 225-362-9935; Rachel East (New Orleans TMC) – 225-379-2576</td></tr>
<tr><td colspan="3">Planned Activities and Tentative Schedule</td></tr>
<tr><td colspan="2">Activities</td><td>Preliminary Dates</td></tr>
<tr><td colspan="2">Visit 1: Kickoff and introduction meeting</td><td>3/17/09</td></tr>
<tr><td colspan="2">TMC builds internal team</td><td>4/1/09</td></tr>
<tr><td colspan="2">TMC completes self-evaluation and identifies Wx integration strategies</td><td>4/13/09</td></tr>
<tr><td colspan="2">Visit 2: Review strategies and discuss integration planning process</td><td>4/28/09</td></tr>
<tr><td colspan="2">TMC team finalizes strategies</td><td>5/1/09</td></tr>
<tr><td colspan="2">TMC team prepares draft of Integration Plan</td><td>6/30/09</td></tr>
<tr><td colspan="2">Visit 3: Review draft Integration Plan</td><td>7/10/09</td></tr>
<tr><td colspan="2">TMC team finalizes Integration Plan</td><td>7/24/09</td></tr>
<tr><td colspan="2">Visit 4 (optional): Review final Integration Plan</td><td>7/31/09</td></tr>
<tr><td colspan="2">TMC completes Integration Plan; provides feedback on use of Guide</td><td>7/31/09</td></tr>
<tr><td colspan="3">Project Approach/Weather Integration Opportunities:
Each of the four TMCs will work through their self-evaluation independently and then meet to discuss the results and identify common and unique weather integration strategies. Working closely with the consultant, they will select a set of weather integration strategies and develop an Integration Plan that outlines how they would proceed to implement the selected strategies in the future. During the process, they will document any possible improvements to the Guide and provide to the consultant.</td></tr>
<tr><td colspan="3">The Consultant’s Planned Involvement:
The consultant team will work through the Guide with the Louisiana TMCs to help them develop their weather integration plan. Three or four visits to Baton Rouge to discuss progress and provide advice will be conducted during the course of the project. Advice may include technical information and examples from other TMCs about specific weather integration strategies that are of interest to Louisiana.</td></tr>
</table>

2.2.2 Tier 2 TMCs

The consultant team provided limited assistance to the two Tier 2 TMCs to carry out their self-evaluations and develop weather their integration plans. These TMCs were asked to identify weather integration strategies and develop an integration plan on their own, without external support. As part of this limited assistance, the consultant visited each site, conducted up to four phone conversations with the TMC lead contact to review progress, answered questions, and provided limited assistance to ensure the TMC was maintaining focus on the tasks and keeping with the schedule, as follows:

- Phone conversation #1: Introduce the process and the self-evaluation Guide. Suggest the TMC identify a mix of TMC staff to work through the Guide. Jointly agree on a schedule for completing the Guide process.
- Phone conversation #2: Check on their status and answer any questions relating to the Guide and their selected weather integration strategies. Review the weather integration plan outline and offer guidance to help assure that the plan fits their needs and corresponding strategies.
- Phone conversation #3: Check on their status and answer any questions relating to the development of their draft weather integration plan.
- Phone conversation #4: Receive their final weather integration plan and discuss other input and feedback to improve the Guide and the self-evaluation and planning process.

Specific deployment plans were prepared and focused on each Tier 2 TMC that defined the activities to be conducted as part of the project tasks. Table 6 and Table 7 provide the deployment plans. Slight schedule alterations were made as necessary to ensure a smooth project implementation.

The next section provides the results of the work each TMC accomplished through the development and implementation of their deployment plans.

Table 6. Weather Information Integration Deployment Plan Overview: Redding, California

<table>
<tr><th>Tier 2 TMC</th><th colspan="2">Redding, California Caltrans District 2 TMC</th></tr>
<tr><td colspan="3">General Description:
This Caltrans District-wide TMC located in Redding, California (north central) manages all the California state highways and Interstates in a large seven-county area. The area experiences heavy rain, flooding, snow at the higher elevations, fires, and high winds. They currently exhibit a low level of weather integration and are very interested in enhancing their capabilities in this area. They represent a large geographic rural area with numerous state highways and Interstates that experience a variety of severe weather conditions that affect the highways and the safety of the traveling public.</td></tr>
<tr><td rowspan="2">Primary Contact:
Clint Burkenpas, District Traffic</td><td colspan="2">Phone: 530-225-3245</td></tr>
<tr><td colspan="2">Email: clint_burkenpas@dot.ca.gov</td></tr>
<tr><td colspan="3">Others Involved:
None at time plan developed.</td></tr>
<tr><td colspan="3">Planned Activities and Tentative Schedule</td></tr>
<tr><td colspan="2">Activities</td><td>Preliminary Dates</td></tr>
<tr><td colspan="2">Phone conference 1: Kickoff and introduction discussion</td><td>4/16/09</td></tr>
<tr><td colspan="2">TMC builds internal team</td><td>4/23/09</td></tr>
<tr><td colspan="2">TMC completes self-evaluation and identifies Wx integration strategies</td><td>5/29/09</td></tr>
<tr><td colspan="2">Phone conference 2: Check status and answer questions</td><td>6/9/09</td></tr>
<tr><td colspan="2">TMC team finalizes strategies and prepares draft Integration Plan</td><td>7/29/09</td></tr>
<tr><td colspan="2">Phone conference 3: Check status and answer questions</td><td>7/31/09</td></tr>
<tr><td colspan="2">TMC team finalizes Integration Plan</td><td>8/14/09</td></tr>
<tr><td colspan="2">Phone conference 4: Receive final Integration Plan and other feedback</td><td>8/26/09</td></tr>
<tr><td colspan="3">Project Approach/Weather Integration Opportunities:
The Caltrans District 2 TMC will be introduced to the Guide and provided instructions on its use. They will conduct the self-evaluation process and be asked to develop an Integration Plan with only a minimum of involvement and assistance from the consultant. Four phone conferences will be conducted to check on their status and answer any questions they may have. Their weather integration opportunities include strategies that would provide better road weather forecasting of storm intensity (amount of rain or snow) and more specific locations (road weather information displayed on map).</td></tr>
<tr><td colspan="3">The Consultant's Planned Involvement:
The consultant team involvement with the Caltrans District 2 TMC will be kept to a minimal level to provide general assistance and check-in phone conferences to track their progress with the self-evaluation, weather integration strategies and preparation of an Integration Plan.</td></tr>
</table>

Table 7. Weather Information Integration Deployment Plan Overview: Cheyenne, Wyoming

Tier 2 TMC	Wyoming Statewide TMC
General Description: The state of Wyoming has one TMC in Cheyenne that manages the Interstates and all state highways that provide the majority of the transportation network throughout this extremely rural state. They primarily experience heavy snow, high winds, and blowing/drifting snow throughout the state. Interstate 80 is a major commercial goods transport corridor that traverses the lower portion of the state. The TMC exists primarily to address severe weather conditions that frequently close important Interstates and state highways throughout the state during the winter months. They currently demonstrate a medium level of weather integration and are very interested in enhancing their weather integration capabilities. They represent a rural statewide TMC with severe weather conditions that significantly impact travel within the state.	
Primary Contact: Vince Garcia, ITS Program Manager	**Phone:** 307-214-0235 (cell) **Email:** vince.garcia@dot.state.wy.us
Others Involved: Kevin Cox, ITS-Systems Engineer; 307-777-4620; kevin.cox@dot.state.wy.us.	
Planned Activities and Tentative Schedule	
Activities	**Preliminary Dates**
Phone conference 1: Kickoff and introduction discussion	4/22/09
TMC builds internal team	4/23/09
TMC completes self-evaluation and identifies Wx integration strategies	5/29/09
Phone conference 2: Check status and answer questions	6/9/09
TMC team finalizes strategies and prepares draft Integration Plan	7/29/09
Phone conference 3: Check status and answer questions	7/31/09
TMC team finalizes Integration Plan	8/14/09
Phone conference 4: Receive final Integration Plan and other feedback	8/26/09
Project Approach/Weather Integration Opportunities: The Wyoming Statewide TMC will be introduced to the Guide and provided instructions on its use. They will conduct the self-evaluation process and be asked to develop an Integration Plan with only a minimum of involvement and assistance from the consultant. Four phone conferences will be conducted to check on their status and answer any questions they may have. Their weather integration opportunities include strategies that would provide the means to automatically control traffic management devices on their Interstates and major state highways (such as variable speed signs).	
The Consultant's Planned Involvement: The consultant team involvement with the Wyoming Statewide TMC will be kept to a minimal level to provide general assistance and check-in phone conferences to track their progress with the self-evaluation, weather integration strategies and preparation of an Integration Plan.	

3.0 Identification of Weather Information Integration Strategies and Plan Preparation at TMCs

This section describes the support provided each of the five TMCs, identifies weather information integration strategies for each TMC, and summarizes the integration plans produced by the TMCs (complete plans are provided in the appendices).

3.1 TMC Self-Evaluation and Development of Weather Information Integration Plans

The consultant team provided varying levels of support for the five TMCs. With assistance provided through periodic conference calls and several site visits, the Tier 1 TMCs all completed the self-evaluation process and developed a weather integration plan. These plans are included in the appendices. The Tier 2 TMCs completed the self-evaluation process with significantly less support and identified weather integration strategies. One of the Tier 2 sites was able to develop an integration plan. The primary reason the other site did not develop a plan was the other demands placed on the TMC that were of higher priority.

Each TMC brought together a group of individuals representing specific functions within the TMC or an outside agency related to the process, to work through the self-evaluation process. These groups understood the range of TMC weather needs, the missions of the TMCs, and the value of establishing close working relationships with stakeholders outside the TMC. The varying perspectives from each member of these working groups were immensely valuable. New working relationships were established and weather information was shared.

The weather integration self-evaluation and planning process is illustrated in Figure 2. The process is divided into three major segments, each with a specific objective as shown in the figure. Segment 1, Self-Evaluation, concludes with a TMC identifying and prioritizing a set of weather related needs. Segment 2, Guidance for Weather Integration, maps the needs to a set of weather integration strategies and provides information about each strategy so that the TMC can select which ones best fit their most urgent needs and their operational constraints. Following selection of the strategies, the TMC is then encouraged to prepare an integration plan that describes in more detail what tasks they will perform to implement the selected strategies. All of the possible weather integration strategies by category and level are described in Table 8.

Twenty-three specific weather information/integration needs in five different categories are reviewed by the TMC as they progress through the self-evaluation process. Each TMC identifies the needs that are specific to its operation and approach to using weather information. Table 9 displays the list of needs including those each TMC in this study identified as its top priority. The table lists the Tier 1 TMCs' needs that they selected to emphasize in the process of identifying their weather integration strategies; other secondary needs were also noted by these TMCs as they went through the self-evaluation process.

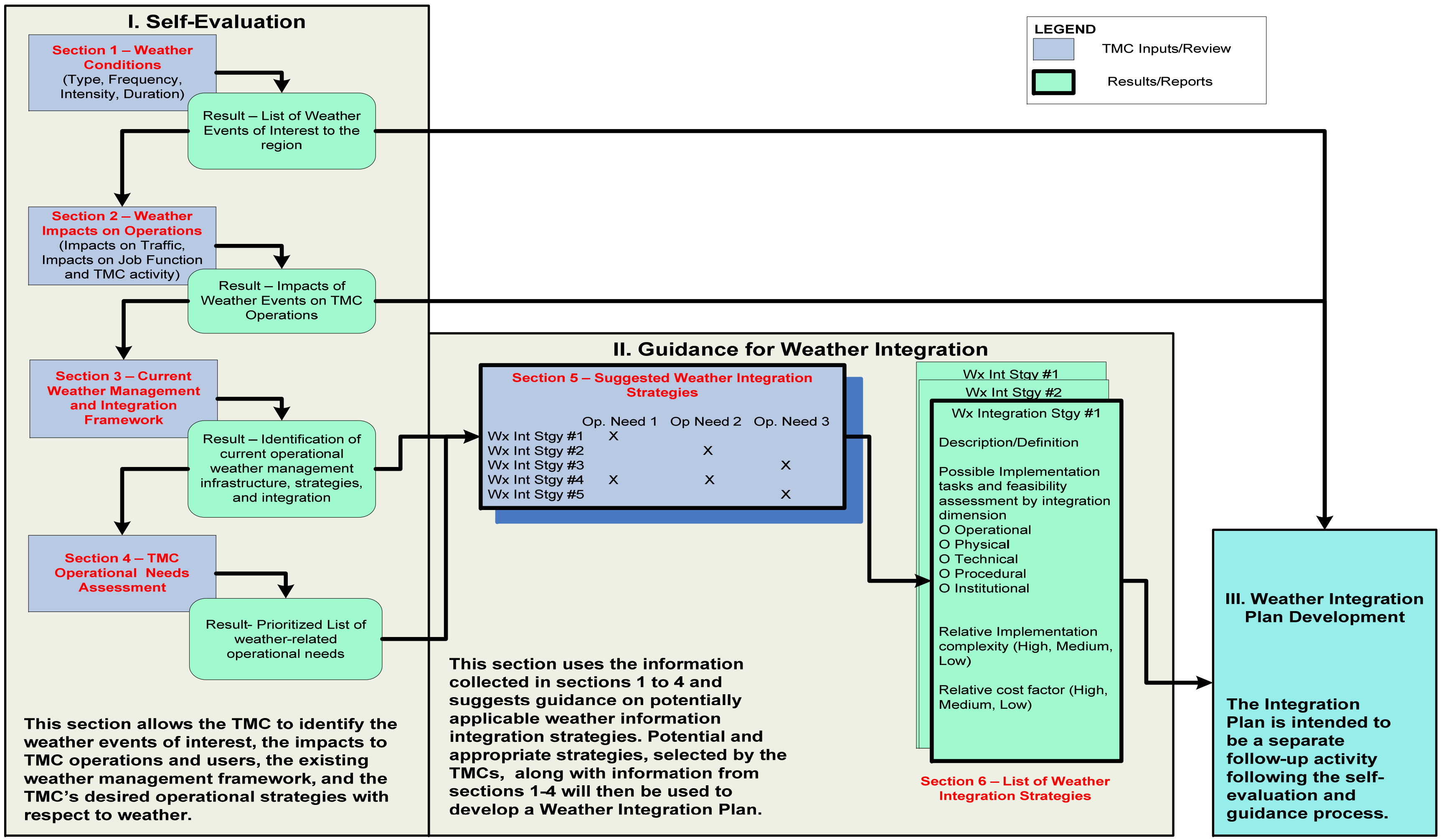


Figure 2. Weather Integration Self-Evaluation and Planning Process

Table 8. Weather Integration Strategies by Category and Level

Items of Integration	Strategies				
	Level 1	**Level 2**	**Level 3**	**Level 4**	**Level 5**
Use of Internal Weather Information Resources	Camera imagery	Radar, satellite, Automated Surface Observing System (ASOS) and Automated Weather Observing System (AWOS) data, and general zone-type forecast information	Level 2 data plus data from Road Weather Information Systems (RWIS) and related networks	Level 3 data plus data from Automatic Vehicle Locations/Mobile Data Computers (AVL/MDC) sources and internal radio communications	Level 4 data with addition of analyzed fields and transformed data parameters (frost index, wind chill, est. snow, ice, water depth)
Use of External Weather Information Sources	General weather information, forecasts, and interpretation provided through media as irregular service (radio and TV weather)	Internet provided, public access general forecasts, weather radar or satellite image or weather-specific broadcast channel	Field observers or probes providing scheduled weather / driving condition information from entire route system	Contractor provided surface transportation weather forecasts targeted at the operational needs of the TMC agencies	Direct connection between private weather information service providers and traffic management software
Availability of Weather Information	Cable channel or subscription weather information vendor providing general weather information	Internet provided weather radar or satellite image on video wall	Field observers or Environmental Sensor Station (ESS) network providing scheduled road or driving condition reports	Vendor provided daily surface transportation weather forecasts and observed weather conditions including Level 3	Meteorologist, located within TMC, forecasting and interpreting weather
Frequency of Weather Forecasts	Receive information of weather forecasts on a request basis	Receive weather forecast once daily.	Receive periodic forecasts several times a day	Receive hourly updates of weather forecasts several times a day	Receive continuous updates of weather forecasts in real-time

Items of Integration	Strategies				
	Level 1	Level 2	Level 3	Level 4	Level 5
Frequency of Weather/Road Weather Observations	Receive information of weather conditions on a request basis	Receive weather observations once hourly	Level 2 plus receive weather/road weather observations when predefined thresholds have been exceeded	Receive weather/road weather observations every ten minutes and when predefined thresholds have been exceeded	Receive weather/road weather observations continuously with data above predefined thresholds highlighted
Weather Information Coordination	Intra-TMC committee tasked with weather information coordination	Identified TMC or maintenance staff member tasked with coordinating weather information at TMC	Dedicated weather operations supervisor	Meteorology staff located within the TMC forecasting and interpreting weather information	Co-location of the Emergency Operations Center/Office of Emergency Management (EOC/OEM)
Extent of Coverage	Sparse Set of Isolated Locations	Network of Scattered Locations	Corridor-level	Multiple-corridor/sub-regional	Regional/Statewide
Interaction with Meteorologists and Climatologists	Focus group or informal gatherings of local professionals from the transportation management and weather communities	Develop check list of routine weather awareness activities	Periodic staff meeting that includes a meteorologist to discuss weather information needs and responses	With a meteorologist present conduct post-event debriefing / regular assessment to fine-tune responses	Daily personal briefings and integrated interruptions by meteorology staff within the TMC
Alert Notification	Monitor media outlets, Internet page, or data stream for critical events	Telephone call list	Manual email/paging system	Automated TMC road weather system-generated notifications (e.g., Email or page from Road Weather Information System or Flood Early Warning System)	Automatic notification through Center-to-Center communications

Items of Integration	Strategies				
	Level 1	Level 2	Level 3	Level 4	Level 5
Decision Support	Ad-hoc implementation of weather management strategies	Use quick-reference flip cards on operator's workstation to implement predefined response	Response scenarios through software supply potential solutions with projected outcomes based on weather / traffic modeling	Automated condition recognition and advisory or control strategy presented to operator for acceptance into ATMS	Automated condition recognition and advisory or control strategy implemented without operator intervention
Weather/Road Weather Data Acquisition	Media Reports	Internet and/or Satellite Data Sources	Across agency intranet and dedicated phone acquisition	Dedicated communications link to state, federal, private data sources	Dedicated communications link to state, federal, private data sources including vehicle-derived weather data

Table 9. Needs that Determined Weather Integration Strategies at Tier 1 TMCs

Weather Integration Needs	Colorado Springs TMC	Louisiana TMCs	Kansas City Scout TMC
Weather Integration Gathering and Processing			
Better short-term forecasts of arrival time, duration, and intensity of specific weather cells (events) at specific locations			
Better prediction of impact of weather events including assessment of reductions in capacity	✓		
Better real-time information on road conditions during weather events	✓	✓	✓
Improve the coverage and granularity of weather information in the region		✓	
Assistance in interpreting weather information and how best to adjust operations in light of that information	✓	✓	✓
Institutional Coordination			
Develop and implement clear, written policies and procedures for handling weather events		✓	✓
Improve coordination within the TMC operations			
More coordinated responses and information sharing with adjacent jurisdictions/regions	✓		
Improve coordination with local public safety and emergency agencies	✓		
More opportunities and mechanisms for communications and exchange with others in the weather community and those with experience dealing with weather events			
Advisory Operations			
Disseminate weather information to a larger set of stakeholders and users in the region (including transit and other modes)			✓
Improve message content (for DMS, 511, HAR, websites etc)	✓	✓	
Improve targeting of weather messages (site-specific, user group specific) to more effectively convey road weather information		✓	
Provide better pre-trip weather information to aid travelers in their decision making	✓		
Provide better en-route weather information to aid travelers in their decision making			✓
Control Operations			
Improve management of emergency routing and evacuation for large-scale weather events			
Improve traffic diversion and alternate routing capabilities			
Improve safety at intersections during weather events	✓		
Improve traffic signal timing during weather events to facilitate traffic movement	✓		

Weather Integration Needs	Colorado Springs TMC	Louisiana TMCs	Kansas City Scout TMC
Treatment Operations			
Assist maintenance in better determining the optimal treatment materials, application rates, and timing of treatments.			
Improve the timeliness of weather management response including deployment of field personnel and equipment			✓
Reduce the time required to restore pre-event level of service operations after a weather event			
Reduce costs of roadway treatment options			

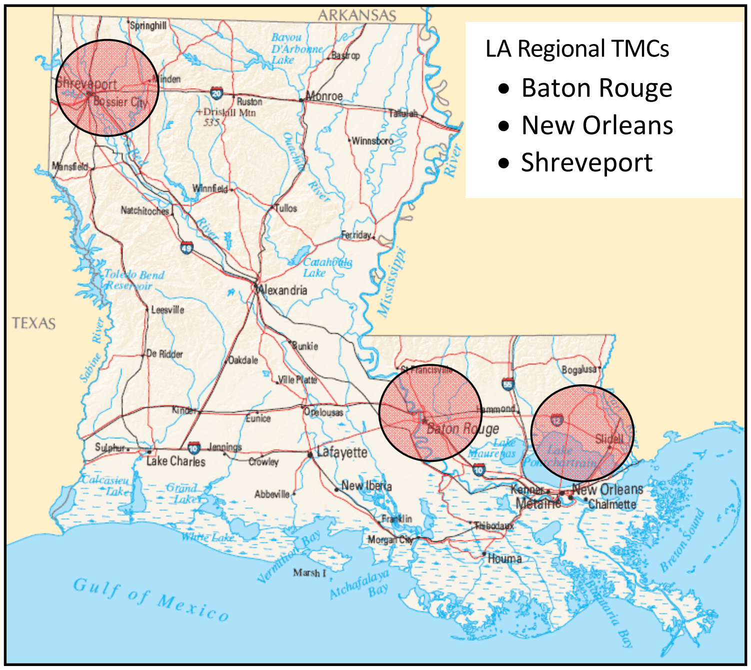
The subsections that follow summarize the efforts each TMC undertook to conduct a self-evaluation and develop an integration plan. The Tier 1 TMCs are described in terms of their operational characteristics, weather integration strategies (that correspond to their needs shown in Table 9), and the implementation plans that were created to guide their integration activities in the coming months and years. The Tier 2 TMCs are described by their efforts to conduct the self-evaluation and develop plans on their own.

3.2 Louisiana Statewide and Regional TMCs

3.2.1 Operational Characteristics

The regional and statewide Louisiana TMC operations staff work closely with one another to monitor and manage the operations of all interstate highways throughout the state. The TMCs operate Closed Circuit Television (CCTV) cameras, Dynamic Message Signs (DMS), Vehicle Detection (VD) devices, and the state's 511/Condition Acquisition and Reporting System (CARS) traveler information system. The TMC Operations Staff also dispatch the Motor Assistance Patrol (MAP) vans, send notification emails to key personnel, and use Twitter to alert motorists of hazardous road conditions. TMC locations are shown in Figure 3.

Louisiana experiences a wide variety of weather patterns across the state that impact road safety and operations. Heavy rain events cause flooding of roadways, heavy fog impairs drivers' visibility, tropical weather activity brings strong winds and heavy rains, and icy storms cause slippery roads. By integrating weather information into TMC operations, staff can inform drivers of hazardous weather conditions on the roads and aid in the reduction of weather-related vehicular accidents.



Source: Map provided by Louisiana TMC

Figure 3. Louisiana Regional TMCs

The Statewide TMC is located in Baton Rouge and oversees all field equipment and operations of the regional TMCs along with field equipment located in areas not covered by the regional TMCs. The Statewide TMC handles all regional based incidents and construction projects. It operates 24/7 and provides after-hour coverage for the regional TMCs.

The Shreveport TMC handles most of the northwest Louisiana area, including Shreveport and Bossier City and the surrounding areas. The interstates located within this area are I-20, I-220, and I-49.

The Baton Rouge TMC covers East Baton Rouge Parish and surrounding areas including Denham Springs, Port Allen, and Prairieville. Several major interstates and junctions are located within the Baton Rouge area I-10, I-12 and I-110.

The New Orleans TMC covers the greater New Orleans area, Kenner, Laplace, and the Northshore. I-10 and I-610 are within the New Orleans area, and I-12 runs through Hammond and Covington on the Northshore.

All incidents or construction in these areas are handled by the regional TMC. Each TMC can assist in any incident by activating DMS, notifying key personnel, dispatching MAP and entering the incident into the 511/CARS system. The TMCs work cohesively to assure all incidents, construction and other projects are proficiently handled.

3.2.2 Weather Information Integration Strategies

The TMC operations staff was able to determine the levels of integration under which each TMC was operating and what intermediate levels needed to be achieved. Based on the needs selected, the target levels of integration were determined by the Guide. Intermediate levels were chosen to provide smaller steps to achieve the target level. Once the selected intermediate steps have been reached, the TMC operations staff will reassess how to approach the next level of integration. This process is repeated until the target level is achieved. Table 10 summarizes the current level of integration, selected intermediate level, and target level defined by the Guide.

Table 10. Current, Intermediate and Target Levels of Weather Integration for the Louisiana TMCs

Items of Integration	Strategies		
	Current Level	Intermediate Level	Target Level
Use of Internal Weather Information Resources	2	3	4
Use of External Weather Information System	2	3	4
Availability of Weather Information	2	3	4
Frequency of Weather Forecasts	0	2	4
Frequency of Weather/Road Weather Observations	0	2	4
Weather Information Coordination	0	2	4
Extent of Coverage	0	2	5
Interaction with Meteorologists and Climatologists	0	2	3
Alert Notification	1	1	4
Decision Support	1	2	3
Weather/Road Weather Data Acquisition	2	2	4

3.2.3 Implementation Plan

The self-evaluation and planning guide lists 11 separate integration strategies that pertain to different areas of weather integration in TMC operations. After reviewing all the strategies it was decided that many of these strategies could be implemented by utilizing the same resources; therefore, the TMC operations staff decided to combine these strategies and organize them in the order in which they were expected to occur. With the integration plan completed, weather integration would be implemented at each TMC during the next two years.

Several activities were planned to be initiated by the TMC operations staff during the implementation process. Most would begin with a written Memorandum of Understanding (MOU) and changes to policies and procedures. With these changes, the roles of the TMC Operations Staff when responding to weather-related events would change, becoming more proactive in response to road/weather information. Activities that were planned to be started at the TMCs during the initial integration of weather information included writing the policies and procedures to integrate weather and traffic information, coordinating with MAP operators and State Police on weather/road observations, and reporting.

Several projects were being implemented by the Department of Transportation and Development (DOTD) that included placing CCTV cameras and DMS in the New Orleans and Lafayette areas. With the installation of new equipment to inform travelers and to be able to monitor incidents and traffic, the TMC Operations Staff anticipated they would be better-equipped to handle weather-related events proactively. The first two years of the plan would be devoted to developing plans and policies and acquiring data in order to provide the necessary resources to manage weather events.

In the first 6 months the TMC Operations Staff planned to identify all weather information sources such as MAP, State Police, and Louisiana State University (LSU). These sources were discussed in the first through fifth and eighth integration strategies. The flow of information would be discussed, so the information could be received and properly used. The goals and plans of the TMCs would then be established, making all participating groups aware of them. Also within this timeframe a weather coordinator would be appointed to write, implement, and direct this plan.

Concurrent with the first set of goals, in the next 12 months, the TMC operations staff planned to develop policies and procedures. These policies and procedures would be developed in order for the flow of information to be utilized properly and efficiently. In these policies and procedures, definitions of advisory thresholds would be defined for statewide consistency. Although agencies and equipment would be different among the TMCs, the standard operating procedures would be the same for each TMC. Also during this time, the pilot sites would be established, and DOTD would develop detailed road device deployment plans for the sites which were discussed earlier, such as the Atchafalaya Bridge, Bonne Carre Bridge, and Red River Bridge.

Within the next 18 months, the pilot sites would be tested with RWIS equipment. During this time the weather coordinator would collect data, and the policies and procedures would be followed in order to ensure that the potential pilot sites were operating correctly. These pilot sites were intended to help determine the usefulness of the equipment and resources.

Within the next two years, the TMC Operations Staff would update the integration plan in order to identify the next steps in the weather integration process. Since the TMC operations staff chose an intermediate level, with the ultimate goal being the target level the Guide originally provided, the Guide would be revisited each year until the TMC operations staff and DOTD had made all the desired improvements for weather integration.

Table 11 lists the integration strategies previously discussed, implementation timeframe, and the sequence in which they should be reached.

Table 11. Integration Strategy Timeframes and Sequencing

Items of Integration	Implementation Timeframe	Implementation Sequencing
Use of Internal Weather Information Resources	1 year	1
Use of External Weather Information System	2 years	2
Availability of Weather Information	2 years	2
Frequency of Weather Forecasts	1 year	1
Frequency of Weather/Road Weather Observations	1 year	1
Weather Information Coordination	2 years	3
Extent of Coverage	5-10 years	4
Interaction with Meteorologists and Climatologists	2 years	1
Alert Notification	2 years	3
Decision Support	2-3 years	3

3.3 Kansas City Scout TMC

3.3.1 Operational Characteristics

Kansas City Scout (KC Scout) is a comprehensive traffic congestion management and traveler information system conceived, designed, and operated jointly by two Departments of Transportation, a fact that is unique throughout the country. In September of 2001, the Missouri Department of Transportation (MoDOT) and the Kansas Department of Transportation (KDOT) jointly announced their bi-state initiative to address traffic impacts on over 100 miles of contiguous freeways intersecting both sides of the state line throughout the greater metropolitan Kansas City area.

KC Scout's goal has been to offer area drivers the latest in technology and communications to help make their daily commute safer, faster and more manageable. Construction was already underway for MoDOT's new District 4 Headquarters in Lee's Summit, MO and it was decided that a state-of-the-art TMC could be housed within the new building. The Federal Highway Administration funded 90% of the initial $35.5 million start up costs, with the remaining funding for the project shared between both state DOTs.

The KC Scout TMC was completed and opened in late 2003 and has become recognized as an innovative leader in ITS deployment with an integrated system of 138 closed-circuit television cameras (CCTVs), 38 dynamic message signs (DMS), 277 vehicle detector stations (VDS), a highway advisory radio (HAR) system and a dynamic web site offering users the capability of designing their own customized alert messaging profiles.

The Kansas City Scout TMC began limited operations in January 2004 with 75 miles of coverage on portions of I-70, I-435, I-35 and several state highways in both Missouri and Kansas. The official public launch was held during a ceremony on September 27, 2004 attended by city, state and federal officials along with media and emergency service providers.

Kansas City Scout encompasses the jurisdictional boundaries of Cass, Clay and Jackson counties in Missouri and Johnson and Wyandotte counties in Kansas. Population for those respective counties is as follows (Table 12):

Table 12. Population Size for Selected Kansas and Missouri Counties

County	State	Population
Cass	MO	95,781
Clay	MO	206,957
Jackson	MO	664,078
Johnson	KS	516,731
Wyandotte	KS	155,509

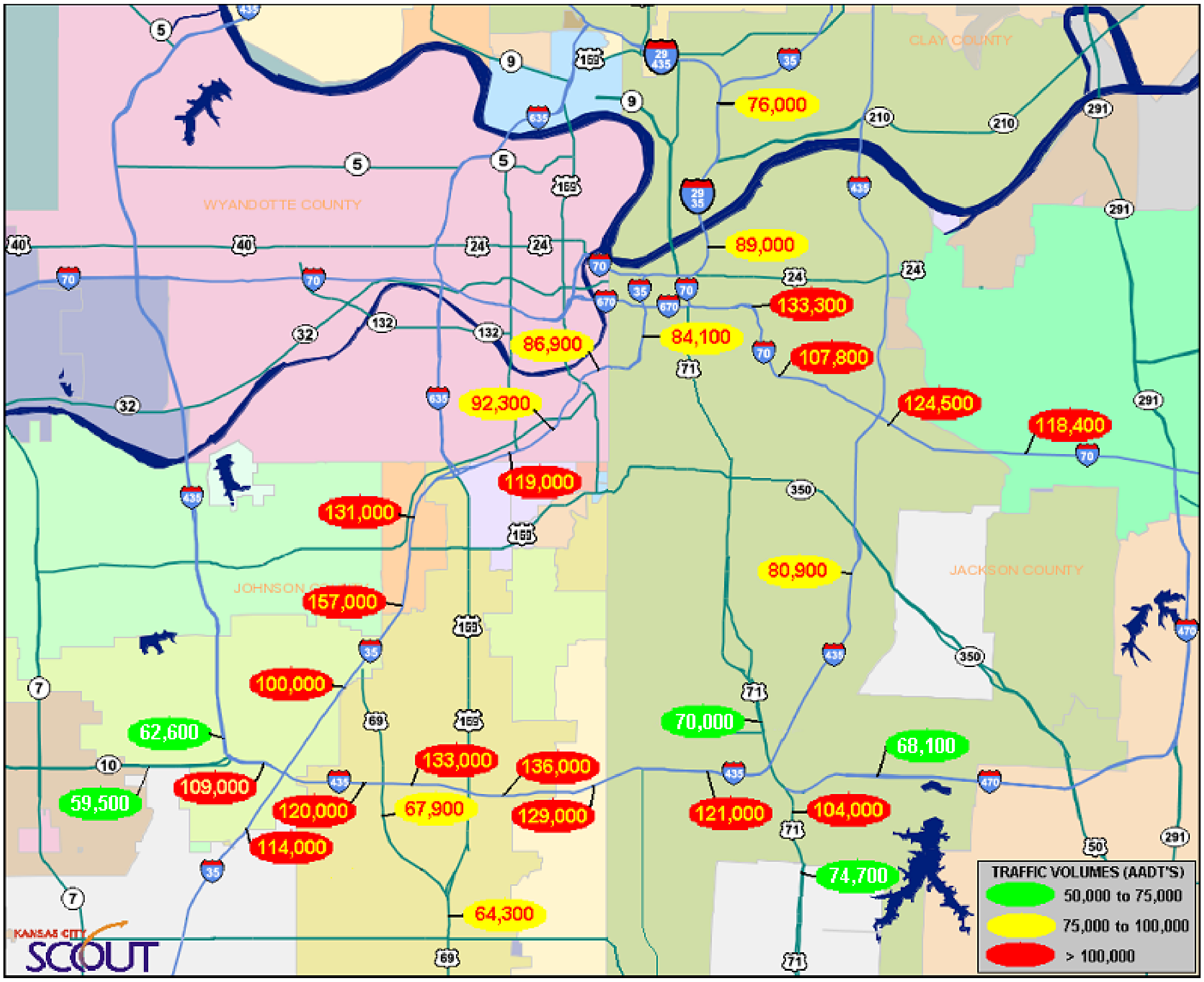
KC Scout has maintained 24/7 operational hours since July 2005. Staffing levels vary between three shifts (6A-2P; 2P-10P and 10P-6A). Peak hours are staffed with a minimum of two operators and one floor supervisor. Due to the collocation of MoDOT's customer service department within the TMC, information relayed to the public is also readily available to Scout operations.

Additionally, KC Scout is supported on both sides of the state line by motorist assist operations. They provide on-the-road assistance to motorists needing help with flat tires, low fuel, etc. and actively patrol the interstates looking for road hazards, tagging abandoned vehicles, and assisting with traffic control on incidents where lane restrictions have occurred due to stalls, accidents, traffic stops or weather impacts, such as flooding, ice covered bridges and overpasses, and debris from storm related events.

KC Scout's coverage area is at the very crossroads of the nation's network of interstate highways with 105 miles of monitored, contiguous roadways carrying high volumes of commercial, commuter and non-local motorists. Therefore, any weather conditions that affect the highways become of critical importance in terms of congestion, accident response, emissions, and driver impatience.

During winter storm events, MoDOT's traffic department staffs a separate workstation within the TMC, solely for the purpose of monitoring road conditions and reporting on the snowplow activity within its local coverage area. This is of great assistance to KC Scout operations because the information can be used to post DMS messages in advance of the plows, helping to keep those lanes clear of through traffic that would otherwise impede plowing activity.

Figure 4 shows Average Annual Daily Traffic (AADT) for the freeway facilities on the Scout system.



Source: Map provided by KC Scout

Figure 4. AADT Data as of September 2009

The I-70 interstate reaches across Missouri from the Illinois state line to the Kansas state line. It is the nation's fifth largest east-west corridor, passing through 10 states from Maryland to Utah.

3.3.2 Weather Information Integration Strategies

KC Scout's work with the Guide yielded a set of target strategies that identified the delta between where the TMC was and where they wanted to be in terms of weather information integration. Those results are shown in Table 13 below.

Table 13. Summarized Levels of Chosen Integration Targets

Integration Item	Current Integration Level	Guide Recommended Integration Level	Chosen Weather Integration Level	Rationale/Comments
Use of Internal Weather Information Resources	2	3	3	RWIS to be deployed in Missouri in 2010
Use of External Weather Information Resources	2	4	3 & 4	Utilizing field and contractor provided data
Availability of Weather Information	2	4	3 & 4	Utilizing field and vendor provided daily surface info
Frequency of Weather Forecasts	4	4	4	Hourly updates several times a day is reasonable
Frequency of Weather/Road Weather Observations	3	3	3	Observations hourly or whenever pre-determined thresholds are exceeded
Weather Information Coordination	0	3	1 & 2	Project team will remain active with project coordinator from TMC
Extent of Coverage	0	5	1 & 2 & 3	Coverage up to corridor level
Interaction with Meteorologists	0	3	1 & 2 & 3	Informal meetings, informational checklists and scheduled sessions with Meteorologist from NWS
Alert Notification	1	4	4	RWIS generated data received electronically
Decision Support	1	3	3	Utilization of 'what if' scenarios for training and projected outcomes
Weather/Road Weather Data Acquisition	2	3	3	Intra-agency and dedicated hotline for notification and advisories

3.3.3 Implementation Plan

Implementation planning is intended to address the steps necessary to achieve their high need objectives. The six target strategies included:

- Disseminate weather information to a larger set of stakeholders and users in the region (including transit and other modes)
- Provide better en-route information on weather conditions to aid travelers in their decision-making

- Develop and implement clear, written policies and procedures for handling weather events
- Improve the timeliness of weather management response including deployment of field personnel and equipment
- Provide assistance in interpreting weather information and how best to adjust operations in light of that information
- Create better real-time information on road conditions during weather events.

Many of the selected strategies involved tasks that were moderate in terms of their complexity and cost to implement. These involved readily available data link connections from external sources and internally developed policies and procedures. In cases where equipment had to be purchased, installed and maintained (i.e., RWIS or Automated Vehicle Location (AVL)/Mobile Data Computer (MDC)) the costs were justified in terms of the added level of service Scout would be enabled to provide.

Scout's TransSuite™ ATMS Software. Providing the core platform for Scout's TMC operation is its state-of-the-art ATMS. Within this framework, CCTVs, DMS and VDS are controlled and monitored.

Prior to September 2009, Scout used a UNIX-based system that furnished little support for enhancement development, report generation or operator efficiency. Many manual workarounds were developed by Scout staff that were time consuming to create and maintain but provided the level of utility desired to create and monitor incidents, track and trend activity, and provide management reporting capabilities. Inbound weather information consisted of daily MoDOT radio broadcasts of WeatherOrNot™ furnished forecasts or Internet-based weather media channels monitored on individual desktops. Scout operators became adept at identifying changing weather conditions while constantly monitoring CCTV cameras spanning 100-plus miles of interstate in the metro KC area. Weather information was more than just a component of the ATMS architecture platform.

On September 1, 2009, Scout successfully deployed TransSuite™ ATMS software. This represented the first major update to Scout's core ATMS platform since the TMC began formal operation in January of 2004. The effort resulted from two years of detailed planning, needs assessment and testing, largely driven by what had been lacking in the legacy system, i.e., scalability, adaptability and ease-of-use. The Windows/SQL-based TransCore™ product deployment was nearly seamless and has streamlined all the processes associated with creating and monitoring traffic incidents, activating and updating DMS message boards and linking all pertinent incident information into easily accessible databases and reporting tools. The user-interface utilizes a series of "layers" that visually represent infrastructure (CCTVs, DMS, VDS), traffic incidents, scheduled events (roadwork) and special events (heavy traffic stadium/concert events).

With this added flexibility, Scout will soon be able to integrate weather information into the user-interface as another "layer" utilizing the lat/long data link connectivity available from external weather information sources, e.g. NOAA, National Weather Service's (NWS) National Digital Forecast Database (NDFD), and Meridian-511 providers. As an example, when a weather condition exists that meets pre-selected alert threshold criteria, a "layer" will "activate" on the operator's ATMS desktop map application, signaling creation of a weather event type "incident" with applicable DMS messaging and outputs to Scout's website and subscriber-configured WebAlert applications. The quickness of being able to notify motorists of a rapidly developing severe weather condition will aid in their decision-making and hopefully reduce severe weather related crashes on the interstate. The next upgrade will accommodate this added weather data functionality. Training on the use of these new elements will require TMC staff development along with support system documentation, but the resources currently exist to complete these efforts.

Partnerships between Stakeholders. Partnerships between stakeholders are well established. Scout's Board of Directors has endorsed this project as a planning mechanism, but all proposed changes would first need to be reviewed and approved before any formal implementation can begin. This board meets every three months but opportunities exist to communicate with them as needed. The board reviewed the Implementation Plan at its meeting on March 25, 2010.

Summary of the Implementation Plan. Figure 5 identifies the specific tasks to be accomplished to achieve the Implementation Plan objectives identified at the beginning of this section. Also the figure illustrates the timeline of activities for each task. Table 14 identifies each task with key inputs and outputs, along with the key responsible KC Scout staff assigned. The information contained in Figure 5 and Table 14 will be used to guide the activities to successfully implement the weather integration tasks.

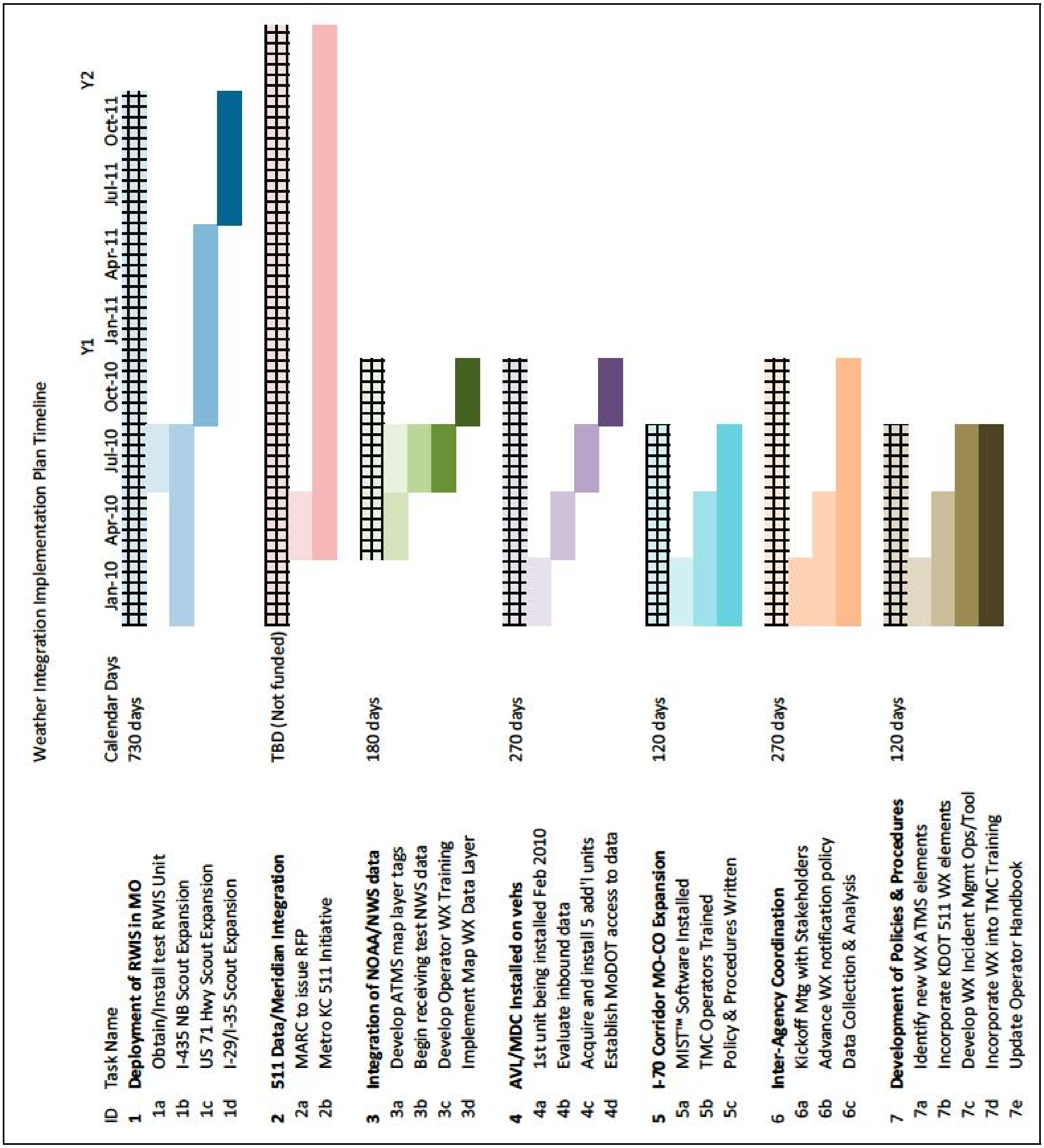


Figure 5. Implementation Timeline

Table 14. Identified Project Tasks for Implementation

ID	Task Name	Owner	Inputs	Outputs	Proposed Timeline	Current Status
1	RWIS Deployment (MO)	Jason Sims (KC Scout)	Contracts awarded Scout expansion -I-435 NB -US 71 Hwy -I-29/I-35	-Realtime Wx data -Improved maint. response time -Accident reduction analysis -Cost/benefit analysis	January 2010 Start (as part of current construction activity on three (3) Scout expansion projects	Delayed to spring 2011, due to need to get power to selected locations
2	Meridian Data Integration from 511 (KS/MO)	Barb Blue (KDOT)	Existing KDOT 511 data -36 sources -24x7 -Road & segment specific -Available *Clarus* data	-Link to Scout website/ATMS -Map layer integration -Threshold targets ID'd	KDOT 511 data available now KC Metro 511 On hold pending funding	KDOT 511 in use and mobile app now offered/ KC Metro 511 still on hold
3	Integration of NOAA datasets enabling alert notification of impending adverse weather conditions	Don Spencer (KC Scout)	-GIS shape files -polygon links	-ATMS Map Layer -Scout specific WX alerts output via Web -Group list notification	Spring 2010	Expect to implement summer 2011 and available by fall 2011
4	AVL/MDC installed on MA/ER vehicles	Jason Sims (KC Scout)	-Road condition data elements -Displayed on TMC operator workstations	-Real-time Wx information -Ability to provide advance info to maintenance personnel	Single evaluation unit to be installed March of 2010 Additional deployments Summer 2010	Deployed in 1/3rd of fleet, with balance pending funding
5	I-70 Corridor Mgmt (from MO to CO)	Jason Sims (KC Scout)	-KDOT Maint & Ops notification of Wx events	-Activation of KDOT Wx messaging and CCTV monitoring	Spring 2010	MO cameras and DMS fully integrated into ATMS by summer 2011
6	Inter-Agency Coordination	Jason Sims (KC Scout)	KDOT, MoDOT, NDOR City of Omaha Topeka TMC	-Proactive Wx messaging -TMC POC specific emails	Summer 2010	On-going integration through ATMS
7	Development of Policies and Procedures Relative to Weather Integration	Nancy Powell (KC Scout)	-Integrated weather layer within ATMS software -Integrated KDOT 511 weather data elements (*Clarus*)	-Incorporate weather incident mgmt into standard operating procedures and training manuals	Summer 2010	On-going, Prelim report expected summer 2011

3.3.4 Post-Implementation Evaluation Planning

As KC Scout continues to deploy their weather integration strategies, they are developing a Post-Implementation Evaluation Plan. Their intent is to assess the ability of their ATMS with integrated weather information to help their operators initiate the actions necessary to proactively respond to forecast weather events through their ATMS, activate the appropriate DMS signage from a predetermined library of approved messages, and manage the event effectively. The expectation is that this system with its enhanced and integrated weather information will result in timelier messaging for the traveling public, along with more proactive internal sharing of weather information between operations and maintenance, and will result in improved highway performance and traveler safety. Figure 6 was used in a meeting with KC Scout to help guide the early planning to evaluate the performance of their ATMS with fully integrated weather information.

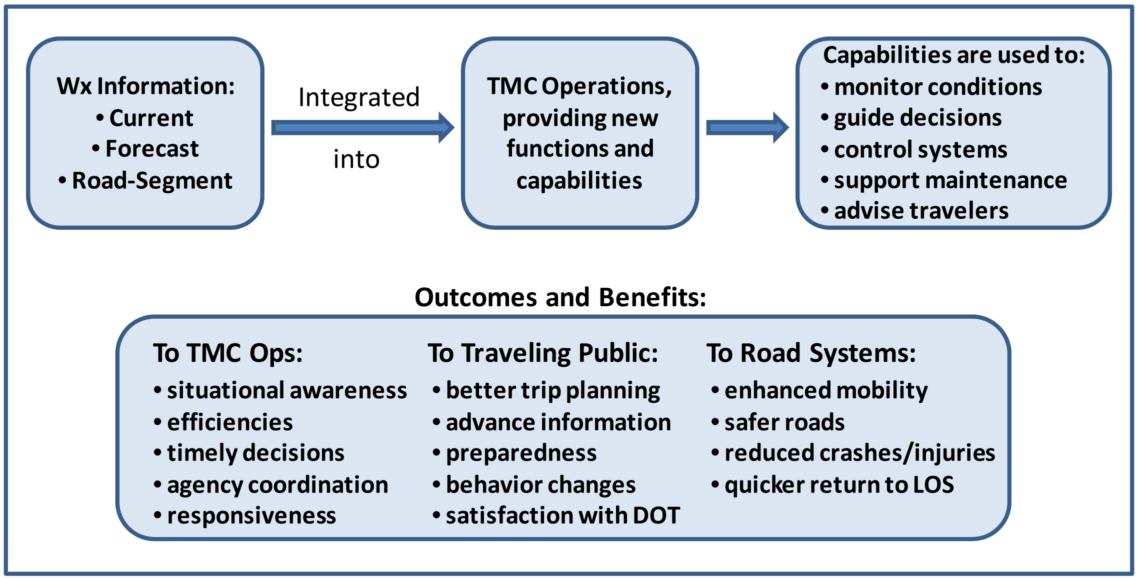


Figure 6. Pathway to Benefits from KC Scout's ATMS Integrated with Weather Information

Although the evaluation plan is not yet prepared, KC Scout is working on how to structure the evaluation. Elements that are under discussion and development at KC Scout include:

- The importance of assuring that the integrated ATMS system is fully functional, that operators have been trained in the use of any new components associated with the acquisition, integration, processing and dissemination of weather information, and enough time has elapsed that the use of the new system has become relatively routine for the operators; that is, with assurance that all or most of the "bugs" have been eliminated.
- The establishment of a fully-functional weather alert notification capability, with alert trigger thresholds that have been defined, implemented, and tested under real world conditions. Ideally, KC Scout will also have new procedures in place that guide the operators in the use of the system and their responses to weather alerts under varying conditions.

- Selection of the evaluation design that will be most appropriate to assessing the achievement of the desired outcomes, allowing KC Scout to attribute the measured outcomes to the effects of their weather integration program, and controlling for the effects of outside factors unrelated to weather integration (for example, other programs that have been developed that might also impact those outcomes, or variability in weather conditions that impact response times and other measured indicators).
- Identification of data requirements to support the evaluation, including sources of data, and specification of the time periods over which data will be needed, both for baseline conditions and post-deployment (if using a “before-after” evaluation design).
- Agreement on the measures of performance effectiveness that will be used in the evaluation to assess the benefits of weather information integration in their operations. Measures of effectiveness are being framed based on the following desired outcomes:
  - Timely posting and removal of weather event messaging to affect motorist behavior
  - Timely communication of weather information to internal and external parties
  - Improvements in maintenance performance due to more proactive weather alerting
  - Savings in areas of maintenance labor and costs associated with shortened time to achieve Level of Service (LOS) linked to the benefits of weather information received from the TMC
  - Reduction in the number of weather-related incidents at high accident locations
  - Improvement in response times to weather related incidents by DOT responders
  - Improvements in the level of customer satisfaction

KC Scout expects their new weather integration system to be operational in summer 2011. The evaluation plan should be complete at this time as well. The system will be tested through the remainder of this winter and through the summer months (strong thunder storms, etc.). The evaluation of the system will continue through April 2013 in order to capture data for two complete seasons.

3.4 Colorado Springs TMC

3.4.1 Operational Characteristics

The Colorado Springs Traffic Management Center (CSTMC) is very unique compared to the other centers in Colorado. It is a regional facility that covers the Pikes Peak region in El Paso County, CO. The center is run and operated by the City of Colorado Springs Traffic Engineering Division instead of by the Colorado Department of Transportation (CDOT). The CSTMC facility houses the Intelligent Transportation System (ITS) equipment and personnel. The ITS equipment includes the signal timing equipment and the computer systems to operate the traffic cameras and Variable Message Signs (VMS). Figure 7 shows a map of Colorado Springs.

Source: Map provided by Colorado Springs, Colorado TMC

Figure 7. Regional Map of Colorado Springs

All fiber communications are managed in the CSTMC. Some of the factual data for the center and the Pikes Peak region include:

- CSTMC incorporates the management and oversight of nearly 564 traffic signals in Colorado Springs.
- The center is open Monday through Friday from 6:30 am until 6 pm. During those hours the City of Colorado Springs is responsible for managing and controlling all the transportation management devices in the region, including the cameras and variables message signs on the I-25 Corridor. The after-hours control of the VMS reverts to the Colorado Statewide Transportation Management Center (CTMC). The after-hours traffic signal control is managed by the City of Colorado Springs through an emergency callout procedure. While the CSTMC is open from 6:30 am until 6 pm, the traffic signal technicians work between 7:30 am – 5:30 pm.
- The CSTMC has a total of 63 cameras and 47 VMS. There are 29 cameras and 31 VMS on I-25. The other cameras and VMS are on arterial roadways.
- There are 28 miles of coverage on I-25 in the Pikes Peak region with approximately 100,000 annual average daily traffic including 8% truck traffic.
- The population in the region is approximately 400,000.

- There are 1,300 roadway miles in Colorado Springs.
- The elevation in Colorado Springs ranges from 6,000 to around 7,000 feet. The highest elevation location on I-25 is on Monument Hill at approximately 7,300 feet.
- The City's Street Division is responsible for servicing over 7,423 lane miles of roadway, extending over a 196 square mile area. The services performed by the Street Division include pavement repairs and maintenance as well as snowfall removal.
- The average annual snowfall is 42 inches.

The CSTMC collects and distributes traffic information. The most common dissemination methods include VMS, Twitter and media releases. The types of traffic information include:

- Traffic Incidents (crashes, stalls, debris, etc.)
- Road work
- Major congestion
- Road weather conditions impacting driving
- Highway/street closures for emergency calls (fire, police, utilities)
- Power/traffic signal outages
- Fires (controlled burns, structure fires, vehicle fires and wildfires)
- Special events (parades, graduations, races, USAFA events, World Arena Events, etc.)
- Traffic campaigns in the State (DUI/seatbelt)
- Accident Alert Status (Cold reporting) for the Colorado Springs Police Department (CSPD) and Colorado State Patrol (CSP)
- Chain law restrictions for commercial vehicles for Monument Hill
- AMBER Alerts

The CSTMC is responsible for traffic signal timing and traffic signal coordination. The computerized Traffic Control System (TCS) allows city staff to continually evaluate and coordinate the City's traffic signals. The City Traffic Engineering staff studies and re-evaluates approximately 30 to 40 arterial streets each year for optimal coordination. The goal of traffic signal coordination is to progress the greatest number of vehicles through the system with the fewest stops and shortest amount of delay.

The traffic signal timing team is comprised of the City's Traffic Engineer and traffic signal technicians who specialize in the timing and coordination of the traffic signals. They gather data, evaluate, and study the major and minor arterial streets. They drive the arterial before and after the new coordination timing is applied to determine the effectiveness and efficiency of the new coordination.

Coordinated signals attempt to provide green lights for the major vehicle flow on a street. This requires that city staff gather data on the volume, speed, distance between signals, and the timing of individual intersections. When the data have been collected a study is done to determine the best timing and coordination of all intersections involved. This may require the timing of the intersections to be adjusted to facilitate the best flow of vehicles.

When the best coordination has been determined the team will implement the new timing plan. Studies are conducted to evaluate the efficiency and to make necessary adjustments. Coordination throughout the city is continually monitored and is reevaluated as needed.

Each arterial has special coordination needs and may require that various types of special timing plans be implemented to help the flow of traffic. To accommodate heavy travel demand periods, it may be necessary to have a long cycle length, and this may cause delays on the side streets. Some arterials may have a heavier flow in one direction. This movement may be favored, causing more stops in the less traveled direction. Some intersections may have lagging left turn movements. This means the left turn arrow comes on at the end of the green through light. There may also be planned stops on long arterials to help maintain the flow of vehicles.

Effective coordination greatly improves the flow of vehicles on the arterial by minimizing the interruption of traffic flow and reducing air pollutants. Other than placing a traffic signal in recall when video camera detection is iced over, the effects of weather on traffic flow have not been considered when establishing signal timing plans in the past. The weather integration plan will allow the staff to develop strategies for modifying signal timing plans in response to specific weather events.

A variety of weather in the region provides a significant challenge to motorists, highway maintenance and traffic signal crews. It also creates havoc with TMC equipment including the traffic signals detection cameras and the highway cameras. The weather systems effecting travel include winter snow storms, high winds, thunderstorms, street flooding and fog conditions.

The climate is very unique within the 194 square miles of the Colorado Springs city limits. While there is only a slight change in elevation in various parts of the city, the actual weather and road conditions can be drastically different at the same time in various locations in the city limits. The weather conditions in the spring and summer produce high winds, thunderstorms with flooding and lightning strikes and foggy conditions. The fall and winter produce high winds, snow storms with blowing snow, heavy snow and occasional extreme low temperatures and occasional foggy conditions.

Weather forecasting information is available from a variety of sources. The CSTMC operators have no set schedule to check the various sources of information.

3.4.2 Weather Information Integration Strategies

The CSTMC analyzed each integration strategy based on the current integration level and the Guide-recommended integration level based on the high priority needs identified in Table 9 above. The CSTMC personnel then determined a chosen weather integration level based on what was thought to be most feasible for the CSTMC. The integration strategies are listed in Table 15 below.

Table 15. Current, Recommended and Selected Weather Integration Strategies

Integration Item	Current Integration Level	Guide Recommended Integration Level	Chosen Weather Integration Level
Use of Internal Weather Information Resources	1	4	3
Use of External Weather Information Resources	2	4	3
Availability of Weather Information	2	4	4
Frequency of Weather Forecasts	1	4	3
Frequency of Weather/Road Weather Observation	1	4	3
Weather Information Coordination	None	4	2
Extent of Coverage	4	5	4
Interaction with Meteorologists	None	3	2
Alert Notification	1	4	3
Decision Support	1	3	2 & 3
Weather/Road Weather Data Acquisition	2	4	3

3.4.3 Implementation Plan

The plan for the CSTMC is to create operator-initiated signal timing plans based on weather observations and predictions. The process involves utilizing the City of Colorado Springs Street Department grid map and performing signal timing modification in each of the 16 grids. It is also a future goal to develop an automated modified signal timing plan in any or all of the 16 grids for weather related incidents. The automation can help reduce the need for after- hour staffing to manage the system.

The CSTMC has elected to conduct a pilot program and the timeline is outlined below. The plan is to utilize just a single grid from the 16 grids available. The project will include fine tuning and evaluating the signal timing plan in the grid selected. At the completion of the pilot project the signal timing plans can be implemented in all 16 grids.

The tasks are split into two categories. One is the weather integration related tasks and the other is traffic signal timing pilot project tasks. Each task and the proposed time frame for both start and completion are listed below in Table 16. Since this timeline was prepared, the demands on limited staff have caused the dates to be pushed out about a year to mid-2011. The pilot test is now expected to be initiated in the spring of 2011, and in anticipation of that, the TMC has begun training technical personnel, and they have installed and are testing several new cameras at selected intersections.

Table 16. Implementation Tasks and Time Frames

ID	Weather Integration Related Tasks	Start	Finish
A1	Collect baseline data in specified locations/grids	12/09	03/10
A2	Refine concept of operations and identify what weather information is needed	01/10	02/10
A3	Obtain training for weather coordinator	01/10	02/10
A4	Establish data triggers, notifications and actions	02/10	05/10
A5	Make adjustments to TMC displays to include cameras, radar and satellite	05/10	07/10
A6	Prepare standard operating procedures	08/10	09/10
A7	Alert notification to the motorist on weather conditions	On-going	
ID	**Traffic Signal Timing Pilot Project Related Tasks**	**Start**	**Finish**
B1	Identify performance measures and prepare plan	04/10	05/10
B2	Develop signal timing plans based on new weather information	05/10	08/10
B3	Provide training for signal technicians on new procedures	09/10	10/10
B4	Implement signal timing pilot project with automation	11/10	03/11
B5	Evaluate effectiveness	11/10	05/11

NOTE: The indicated start and finish dates have slipped approximately one year since this schedule was prepared.

3.5 Wyoming Statewide TMC in Cheyenne

The statewide TMC in Wyoming is one of the Tier 2 sites that received limited support for their weather information integration self-evaluation and planning process. They undertook the process on their own and prepared a weather integration plan that they are currently beginning to implement. Their operational characteristics, integration strategies, and implementation plan are discussed below.

3.5.1 Operational Characteristics

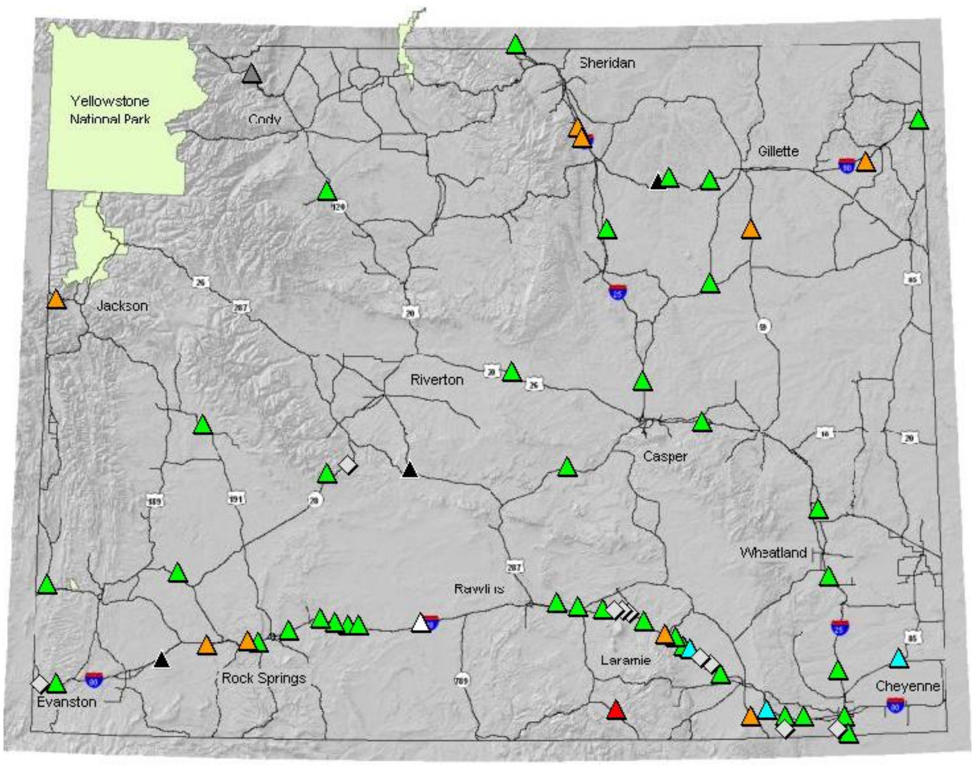
Wyoming DOT's (WYDOT) statewide TMC became operational in the fall of 2008. The TMC is housed in the basement of the Qwest building at 6101 Yellowstone Road in Cheyenne, Wyoming, approximately a mile north of the WYDOT headquarters complex. The TMC houses both the emerging ITS operations function and a new dispatch center for the Wyoming Highway Patrol.

While numerous states already have similar TMCs in operation to deal with urban traffic congestion, Wyoming's center is geared almost exclusively toward rural travel management and information needs that result from extreme weather conditions. Additionally, it is one of the few TMCs where communication services for DOT construction, traffic, and maintenance functions are co-located with law enforcement. The functions of the TMC have expanded over time, but the core functions can be grouped into the following four main areas:

- **Monitoring and control of roadside ITS devices** such as web cameras, RWIS, Variable Speed Limit (VSL) signs, DMS, HAR, flashing beacons, and road closure gates;

- **Serving as a law enforcement communications hub** for state and federal agencies by maintaining frequent contact with Highway Patrol troopers and other personnel via the State Law Enforcement Communications Systems (SALECS);
- **Managing communication with the traveling public** via the 511 Travel Information Service (telephone and internet components) and direct contact with media outlets, visitor centers, and truck stops;
- **Receiving and relaying road and weather reports** from volunteers participating in the Enhanced Citizen-Assisted Reporting (ECAR) program, as well as, dispatching WYDOT construction and maintenance crews throughout the state.

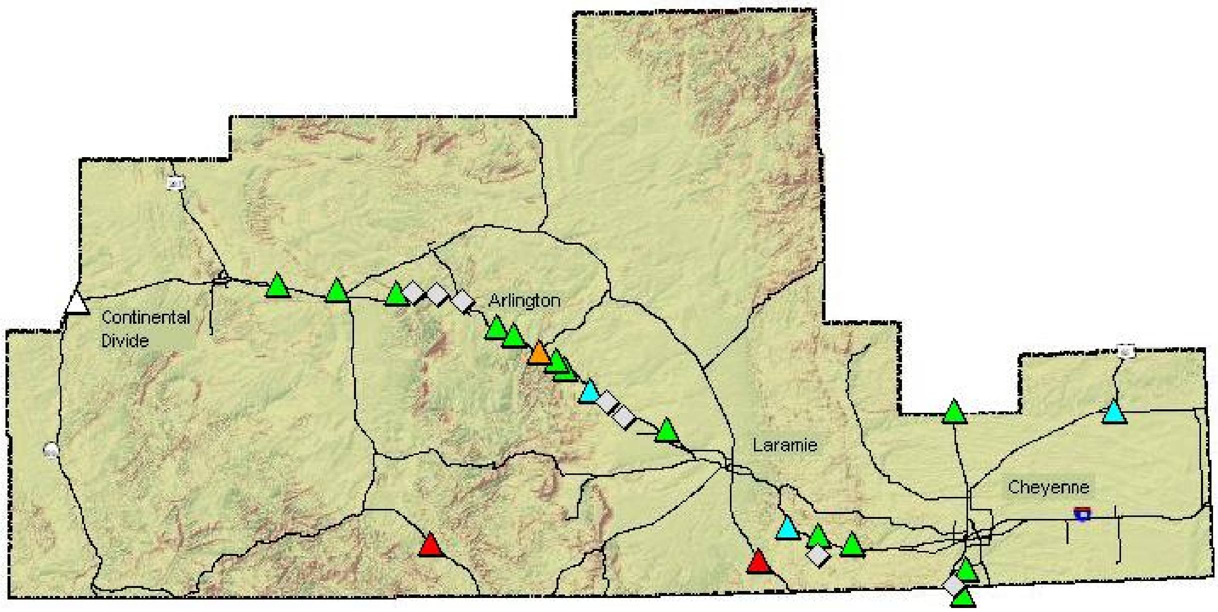
Currently, WYDOT has a network of 62 RWIS stations located throughout the state. They are managed by a central software system known as SCAN Web. Figure 8 and Figure 9 that follow are screen shots from that software, showing the statewide network, followed by a more detailed map of southeast Wyoming where WYDOT has deployed a greater density of RWIS for a 52-mile VSL corridor between Laramie and Rawlins.



Source: Screen shot from WYDOT's SCANweb system.

Figure 8. RWIS Locations Statewide

The VSL corridor is the first of its kind in Wyoming. It consists of a 52-mile stretch of Interstate 80 from Walcott Junction (20 miles east of Rawlins) to Quealy Dome Interchange (17 miles west of Laramie). In that 52-mile corridor, WYDOT now has 13 RWIS stations. This project represents the first corridor-level RWIS deployment in WYDOT's history.



Source: Screen shot from WYDOT's SCANweb system.

Figure 9. RWIS in Southeast Wyoming

3.5.2 Weather Information Integration Strategies

Table 17 provides a summary of WYDOT's integration strategies. The table shows WYDOT's current level for each integration item, the recommendation from the self-evaluation guide, the integration level selected by WYDOT for both the current (C) timeframe, and future (F) timeframe, and comments for each integration item.

Table 17. Summary of Integration Strategies

Integration Item	Current Integration Level	Guide Recommended Integration Level	Chosen Weather Integration Level (C/F)*	Rationale/Comments
1: Use of Internal Weather Information Resources	3	3	3/4	C=expand RWIS locations; F=outfit & receive data from plows & other vehicles
2: Use of External Weather Information Resources	4	4	4/4	Build integrated weather information tool to assist TMC operators
3: Availability of Weather Information	4	4	4/4	Availability meets current needs
4: Frequency of Weather Forecasts	4	4	4/4	Frequency meets current needs
5: Frequency of Weather/Road Weather Observations	2	3	3/3	Expand coverage and frequency of plow driver reports
6: Weather Information Coordination	None	3	3/3	Contracting with a part-time local meteorologist to perform weather information management tasks in TMC.
7: Extent of Coverage	2	4	4/5	C=Adding four more VSL corridors throughout the state; F=continued expansion of RWIS sites.
8: Interaction with Meteorologists	1	3	4/5	See item 6 above.
9: Alert Notification	4	4	4/4	Enhance alert notification in phases (use SCAN Sentry, expand METalert , build new alert system w/ new Wx info tool).
10: Decision Support	1	3	3/4	C=automated recommendations for VSL system; F=expand to DMS recommendations.
11: Weather and Road Weather Data Acquisition	4	4	4/5	C=continue current acquisition; F=automated data collection from DOT vehicles.

*C/F=**C**urrent plans (within next 1-2 years)/**F**uture plans (beyond 2 years)

3.5.3 Implementation Plan

The integration strategies can be grouped into the following seven implementation tasks or projects:

1. **RWIS Expansion** - Expand RWIS coverage throughout state, and multiple corridor RWIS projects. Start by doing a gap analysis, and seek input from District Maintenance offices to determine desired locations. With that, WYDOT can develop an RWIS expansion plan, and

budget for new RWIS on an annual basis to complete the desired expansion in approximately the next five years.

2. **AVL/MDC** - Expand vehicle weather data transmission to TMC from plows with AVL/MDC. This will include continued deployment of their current AVL system statewide. For the MDC component, WYDOT will use its systems engineering process to ensure all requirements are met, including integration with the current AVL system.
3. **Weather Information Manager (WIM)** - Employ part time, contracted meteorologist as weather information manager. This individual will help implement much of this plan, assist the TMC operators in managing and utilizing current and future weather information, and provide a primary point of contact for all weather information resources within WYDOT.
4. **VSL Expansion** - Add Variable Speed Limit (VSL) in four locations and continue to expand in statewide corridors. One of these four new corridors, a VSL project in the Rock Springs - Green River corridor on Interstate 80, was completed and became operational on January 31st, 2011. Two more of these four will be operational by October 2011, and the fourth corridor is currently schedule to be constructed in 2012.
5. **Weather Information Tool** - Build integrated weather information tool to assist operators. Deploy portions of this for commercial vehicle and general public use. The weather information manager will be instrumental in developing this system. That person will also be responsible for keeping the information in this tool timely and accurate.
6. **Weather Alert Notification** - Expand/enhance alert notification system in phases: 1) using SCAN Sentry 2) expanding METalert system 3) using the new integrated weather integration tool/database. SCAN Sentry is presently available to the TMC; it just needs some fine tuning on the configuration and some additional training for the operators. METalert is also available, but additional features (e.g. visibility alerts) could be very useful for the TMC operators.
7. **ATMS Decision Support** - Expand decision support tools, starting with VSL and moving to DMS recommendations. This will include some software development work for our existing ATMS to provide such recommendations based on weather and traffic information.

Table 18 shows the schedule and estimated cost (initial and O&M) for each of the seven projects identified above.

Table 18. Project Timeline and Costs

Project	Start	Completion	Initial Cost	O&M Cost
RWIS Expansion	Ongoing	2015	$ 2,000,000	$ 400,000/year
AVL/MDC	2011	2017	$ 800,000	$ 100,000/year
WIM	Ongoing	N/A	N/A	$ 100,000/year
VSL Expansion	Ongoing	2014	$ 3,000,000	$ 200,000/year
Wx Info Tool	2011	2013	$300,000	$15,000/year
Wx Alert Notification	Ongoing	2013	$20,000	$3,000/year
ATMS Decision Support	2011	2013	$150,000	$15,000/year

Many of these projects are underway and at least partially funded. The scopes of these projects may need to be slightly re-defined to meet the needs identified in WYDOT's plan.

3.6 Redding, California TMC

The Caltrans District 2 TMC located in Redding, California is the second Tier 2 TMC that received limited support for their integration planning. They conducted their self-evaluation using the Guide, and identified a set of weather information integration strategies consistent with their indicated priority needs. However, the pressing immediate demands on their time and resources to operate the TMC did not allow them to prepare an integration plan.

The Redding TMC identified a list of weather information integration strategies that are presented below. It is uncertain whether these strategies will be implemented at the TMC.

3.6.1 Weather Information Integration Strategies

Table 19 provides a summary of Caltrans District 2 TMC integration strategies. The table shows their current level for each integration item, the recommendation from the self-evaluation guide, the integration level selected by Caltrans, and comments for each integration item. Their chosen weather integration level by integration item was fairly conservatively identified due mainly to extremely constrained resources to support implementation. As shown in the table, many of the integration items were not addressed and would need to be considered as possible future items.

Table 19. Summary of Integration Strategies

Integration Item	Current Integration Level	Guide Recommended Integration Level	Chosen Weather Integration Level	Rationale/Comments
1: Use of Internal Weather Information Resources	3	4		Possible future consideration
2: Use of External Weather Information Resources	3	4		Possible future consideration
3: Availability of Weather Information	3	4		Possible future consideration
4: Frequency of Weather Forecasts	3	4		Possible future consideration
5: Frequency of Weather/Road Weather Observations	2	4	3	Bring more Wx info, more often, into the TMC.
6: Weather Information Coordination	none	4	1	Combine with Item 8. Establish coordination committee within the TMC.
7: Extent of Coverage	4	4		Possible future consideration
8: Interaction with Meteorologists	1	3	2	Combine with Item 6. Establish relationships with NWS and obtain assistance.
9: Alert Notification	2	4		Possible future consideration
10: Decision Support	1	3	2	Prepare quick reference flip cards
11: Weather and Road Weather Data Acquisition	3	4		Possible future consideration

4.0 Implementation and Evaluation of Sacramento RTMC Weather Alert Notification System

The Caltrans District 3 Regional Transportation Management Center (RTMC) has been participating since 2007 in the FHWA weather information integration study to identify strategies to enhance TMC weather integration in support of operations, to implement selected strategies, and to participate in an evaluation of the results of their strategy implementation. The RTMC has utilized the FHWA TMC Weather Integration Self-Evaluation and Planning Guide and also prepared a weather integration plan. This section focuses on a strategy they implemented to integrate road-weather information into the RTMC operational advisory functions by implementing an automated weather alert notification system. This system is expected to provide timely traveler and road weather information to the public, particularly regarding fog, wind and frost conditions that can severely affect travel safety and mobility. This section briefly summarizes the implementation and evaluation of the system. A separate, stand-alone report[6] provides more detailed information on those efforts.

4.1 Sacramento's Weather Information Integration Plan

The Sacramento RTMC identified the following weather integration strategies using the Guide:

1. **Frequency of road weather observations** – identify the time intervals for collection of environmental sensor station data. This will reflect the level of detail for information that is required by the RTMC for decision making.
2. **Extent of coverage** – identify additional observations beyond the present environmental sensor station coverage that are required to provide the needed weather information for various road weather conditions to support RTMC decision making.
3. **Weather information coordination** – assign responsibility to an RTMC staff member for coordination of weather information/integration related activities, including training.
4. **Alert notification** – provide automatic alerts to RTMC personnel (and potentially others) when certain weather condition thresholds are exceeded.
5. **Road weather data acquisition** – identify the road weather data, including forecasted road weather conditions, needed to support RTMC decisions. Additionally, identify the level of technological sophistication needed to process and manage weather data.

[6] Cluett, C. and Kitchener, F. (2010). *Implementation and Evaluation of the Sacramento Regional Transportation Management Center Weather Alert Notification System.* (Report No. FHWA-JPO-10-063. NTL No. 14969). Washington, DC: Federal Highway Administration.

6. **Use of external weather information sources** – identify the appropriate weather information sources, observed and predicted, not owned by the RTMC or other state agencies. Additionally, identify the integration techniques to incorporate these information sources into the RTMC decision-making processes.
7. **Decision support** – identify procedures and tools to integrate road weather information into the RTMC decision making processes.

There are overlaps among each of these strategies, and these interrelationships are an important consideration when planning implementation tasks. The Sacramento RTMC's primary goal was to provide alert notification to their operators regarding existing weather conditions so that more effective public advisory notification actions could be taken in a more timely manner. The other strategies listed supported that goal. It was also decided to focus the weather integration strategies on operations associated with the Sacramento Valley.

4.2 Alert Notification System Implementation Objectives

In order to enhance their operational performance, particularly during severe winter weather events in the Sacramento Valley, the RTMC implemented a series of activities in 2009 to achieve the following five main objectives:

1. Improved coordination of operator response and decision making regarding the posting of traveler advisories during severe weather conditions;
2. Enhanced weather information coming into the RTMC;
3. Implementation of an automated alert notification system that would improve operational awareness of and response to severe weather;
4. Refined operational procedures to guide efficient and appropriate operator response to weather conditions; and,
5. Development and implementation of a training program to enhance awareness and strengthen the capability of operators to proactively use weather information, weather warnings and alerts in RTMC operations and in posting and removing advisory messages.

4.3 Alert System Implementation Tasks

The RTMC management committed to implementing the weather alert notification system through a series of tasks carried out during 2009, as follows:

1. Identify and assign an RTMC weather coordinator.
2. Identify weather information sources (observations and forecasts) and determine what is needed in addition to sources already available and access by the RTMC.
3. Properly calibrate and maintain Caltrans-owned road weather observation sensor sites.
4. Identify, procure and install additional weather observation systems.
5. Define alert mechanisms and thresholds, procedures, and timing.
6. Implement the weather alert notification system.
7. Define and implement a training program for operators and others.

Responsibilities were assigned, a schedule was established, and by December 2009 automated weather warnings and alerts were being delivered to operators 24/7 in the RTMC.

4.4 Evaluation Approach

Quantitative and qualitative data were collected to support evaluation measures in both the baseline ("before") and post-deployment ("after") periods. The quantitative data included weather condition readings from a set of RWIS sensors, records of warnings and alerts issued before and during weather events, information on messages posted on electronic signs in the valley, and operator entries in the Computer Aided Dispatch (CAD) TMC logs. The qualitative data were obtained through interviews with operators and managers of the RTMC, and they included observations and perceptions of changes and benefits being derived from the implementation of the weather alert notification system, and also institutional and organizational benefits received as a result of using this system. Data were collected throughout the baseline period of the implementation, and again after the strategies had been implemented and were operational for a period of time.

The evaluation focused on a few significant weather events during which the alert notification system was active. These events were analyzed in detail to understand how well the warnings and alerts tracked the actual weather conditions and how well the operators were able to use those warnings and alerts in supporting their decisions to post messages for the public. The evaluation also addressed the institutional process by which management sought to implement the system, make adjustments based on their real-time experiences with the system, and incorporate feedback from the operators.

The evaluation analysis compared outcomes between the "before" and "after" periods as a basis for identifying changes and benefits that could be attributed to the new integration strategies. Lessons learned were derived from the total implementation experience for the benefit of Caltrans and other TMCs that are considering enhancing their own level of weather integration.

4.5 Baseline Conditions and Challenges

The information collected during the baseline evaluation period identified needs that were closely aligned with the selection of weather integration strategies the RTMC intended to pursue and the tasks identified in their Implementation Plan. Table 20 below summarizes the primary baseline condition findings and corresponding implementation plan tasks that addressed these issues.

Table 20. Summary of Baseline Conditions and the Relationship to Implementation Plan Tasks

Baseline Conditions and Challenges	Implementation Tasks
General lack of focused and coordinated use of weather information.	Task 1: Identify and assign a RTMC weather coordinator.
RWIS sensors inaccurate and unreliable. No confidence in sensor data.	Task 3: Properly maintain/calibrate Caltrans RWIS data stations.
Lack of knowledge of all possible weather information sources that could be used to identify or confirm weather events.	Task 2: Identify weather information sources (observations and forecasts) available or accessible.
Lack of coverage of sensor data, mostly in areas that experience dense fog.	Task 4: Identify, procure, and install additional weather observation systems.
Too much dependency on field personnel to determine when a weather event begins and ends – their input is not always accurate or timely.	Task 5: Define alert mechanisms, thresholds, and procedures. Task 6: Implement weather alert system.
Lack of procedures or guidance regarding operations during inclement weather events.	Task 5: Define alert mechanisms, thresholds, and procedures.
Inconsistent response by the various RTMC operators during weather events.	Task 7: Define and implement training program.
Difficult to know when a weather event is beginning.	Task 6: Implement weather alert system.
Difficult to know when a weather event has ended.	Task 6: Implement weather alert system. (Note: future enhancements to the alert system are planned to address the issue of when events end.)
Significant delays between when an event begins and when signs are activated	All Tasks: Implementation of a weather alert system, operator training, and consistent use of operational procedures.

4.6 Alert Notification System Implementation

The RTMC management decided to build their automated alert notification system by activating a feature of the SCAN Web[7] system (called SCAN Sentry) that issues email alerts when certain conditions (weather data thresholds) are met. This approach is limited to the six RWIS station locations in the Sacramento Valley and was selected as the easiest and least costly way to get an alert system up and running. The RTMC management saw this as a way to test and demonstrate how an alert system might help the operators, with the thought that it could be expanded in the future if it

[7] SCAN Web® is a registered trade mark of Surface Systems, Inc.

proved successful. The results of this evaluation will help the RTMC management decide if an expanded alert system is required to continue improving weather responsive operations.

The following is a summary of how the implemented alert system works:

1. Weather data from the six RWIS stations identified in Task 2 are posted every 10 minutes to the SCAN Web database. This includes all sensor data available at each location.
2. The SCAN Sentry system (software routine with access to the SCAN Web database) compares the weather measurements to the established warnings and alerts. The warnings and alerts identified above were incorporated in the SCAN Sentry system by RTMC management.
3. When the warning or alert conditions are met based on established thresholds, an email is sent to RTMC management and operators.
4. The SCAN Sentry system allows the manager to limit the number of alerts issued if the conditions persist. The maximum time (suspend time) between alerts is 3 hours. If a wind event continues to exceed (or repeatedly fluctuate through) the threshold for several hours, or even days, the operator will continue to receive alerts every 3 hours (but, not every 10 minutes).
5. The SCAN Sentry system does not have the capability of issuing an alert when the thresholds are no longer met, or not met for a given period of time, so operators are not alerted when weather conditions drop below thresholds. This is a limitation that the RTMC management would like to rectify with a new alert system in the future (second approach above).

The SCAN Sentry alert system was activated in the fall of 2009 and began issuing warnings and alerts based on the established weather data thresholds.

4.7 Alert Notification System Performance

Four significant fog and wind events that occurred between December 2009 and April 2010 were selected for a careful assessment, as case studies, of the performance of the weather alert notification system. These included:

1. A fog event that occurred December 17-18, 2009. While fog persisted throughout the valley over these two days, visibility conditions actually dropped below the indicated threshold in two distinct periods such that, for the purposes of assessing messaging performance, this can be interpreted as two separate fog events over this period of time.
2. A particularly severe and persistent wind event that occurred January 17-21, 2010, resulting in 176 alerts being issued.
3. A wind event that occurred March 12-13, 2010.
4. A wind event that occurred April 27-28, 2010.

Each event was evaluated with regard to 1) the timing and duration of the event, trends in the weather measure (sight distance for fog, average sustained speed and gust speed for wind, and temperature for frost) and when those measures crossed their pre-defined threshold, 2) the timing of issuance of automatically generated warnings and alerts that were received by RTMC operators via email, and 3) the timing of traveler advisory message activation and deactivation by the operators during the event. In assessing the RTMC operator responses to these weather events, several indicators were considered:

- Were the warnings and alerts issued appropriately and according to the designated thresholds?
- To what extent was the event covered by messaging to the public?
- Were the appropriate message signs activated based on receipt of alerts and readings from the various sensor sites?
- Were signs deactivated in an appropriate and reasonably timely way?
- Did the operators record information about the event and their decisions in the TMC log?

Follow-up interviews were conducted with four of the RTMC operators in June 2010 after they had experience with the weather alert notification system. The purpose of this interview was to learn how the alert system has been working from the operators' perspective. Some of the same questions were addressed for this interview as had been covered in the baseline interviews conducted a year earlier. Operators in the follow-up interviews were asked to describe how they used the new alert system and whether it was helpful to them in improving the efficiency of their messaging decisions. The new procedures were discussed along with the factors operators consider when making advisory decisions. The analysis of some of the weather events from this evaluation were shared with the operators.

4.8 Evaluation Findings and Lessons Learned

The evaluation of the Sacramento RTMC weather alert notification system examined several adverse weather events in some detail in order to assess quantitatively how the alert system was performing and how the operators were able to use it in supporting their operational decisions regarding posting of advisory messages. The quantitative analysis focused primarily on the post-implementation data obtained from the RWIS sensors, the alert system records, and message sign records. Qualitative findings are based on interviews with selected operators before and after the implementation of the alert notification system.

The quantitative findings include the following:

- **Timeliness of Alerts**. Alerts should be issued to coincide with the start of an event, when conditions exceed the defined threshold. Across the four event periods analyzed, alerts were issued for the most part in a timely and accurate way; that is, 16 out of 18 times (for individual RWIS sensors) they were issued within +/- an average of 10 minutes of the time when the weather condition broke its defined threshold value at the beginning of the event. This is virtually right on time, given measurement error. **Interpretation:** The alerts were mostly well timed, indicating the alert notification system was working as planned.
- **Timeliness of Message Activation.** The RTMC aims to have messages posted on appropriate message signs for the duration of a weather event that exceeds the defined threshold. Fifteen individual sensor-reported weather events that exceeded threshold and/or lasted longer than 16 minutes should properly have had weather warning messages posted throughout those events; 13 of them did and two had no messages posted. For those event segments with some message coverage, coverage ranged between 27% and 100% of the

duration of the event. Out of the 13 events with message coverage, 11 had coverage over 75% of the duration of the event. **Interpretation:** Messaging coverage was generally good but not complete. However, coverage improved over the duration of the evaluation from December 2009 to April 2010, suggesting that the alerts were helping operators post messages more appropriately.

- **Adequacy of Messaging Coverage.** The second dimension of messaging adequacy related to the posting of messages triggered by sensor alerts on the primary signs near the sensor site. As discussed in this report, there are a number of mitigating circumstances that might reasonably prevent posting weather messages on some of these signs. For example, during road emergencies the signs may be needed for traveler alerts, and during mountain snow events, some valley signs may be used for chain control advisories. Nevertheless, across all these case study events, the number of CMS, EMS and LED signs used was significantly less than the number of signs recommended in the RTMC policy guidelines. For the December fog event, out of 8 opportunities to activate primary signs for significant events, only 2 were used, along with 2 out of 8 secondary signs. For the three wind events taken together, out of 43 opportunities to activate the primary signs for significant events, 12 were used (28%). However, the ratio of messaging on primary signs improved over time, with 7 out of 17 (41%) used in the April wind event. **Interpretation:** A low number of primary message signs had messages posted during the weather event case studies examined, but coverage improved over the course of the evaluation period, presumably due to the operators' increasing familiarity with and understanding of the new procedures.
- **Timeliness of Message Deactivation.** Once a message has been posted advising the traveling public about an existing severe weather condition (e.g., dense fog, high winds, frost on road), the operators need to periodically monitor conditions. They need to remove the message after the weather condition has abated and it is reasonable to assume it is not about to return to threshold conditions soon. This is a judgment call, as the alert notification system does not provide explicit guidance regarding when a weather event is over. The alert notification system will continue to provide warnings and alerts in three hours or longer intervals as long as the weather conditions persist, which is helpful to the operators in maintaining their awareness of the status of these conditions. It is considered prudent to leave a message active for a while as conditions are improving in order to avoid frequently activating and deactivating messages. On the other hand, leaving a weather warning message posted long after the event is over may lead to a loss of public trust in the messages. The RTMC management is considering how their alert notification system might be able to issue an "all clear" signal based either on the length of time that passes after last crossing the threshold with an improving trend or the time when conditions reach a designated level after last crossing the threshold.

  For 14 sensor-covered event segments for which messages were activated among the four case studies, the period from the end of the event to message deactivation ranged from 18 minutes to 8 hours and 44 minutes. This extended period of message activation equaled an average lag time of 4 hours and 14 minutes. This is the average period of time during which a message was posted on a roadside message sign indicating an adverse weather condition after that condition no longer exceeded the defined threshold. Without knowing the detailed circumstances associated with each of these events, it is not appropriate to make a definitive judgment about them. For example, operators often rely on CHP in the field to verify conditions for activating messages, but after the weather has improved, CHP is usually no longer available at those locations to advise the operators to deactivate the message.

Interpretation: While the RTMC has not specified an appropriate amount of time to leave a message actively displaying an advisory about weather that has since subsided, nor implemented alerts to signal that time for the operators, the experience with many of these sensor-covered event segments shows there were a number of periods during which messages were left active much longer than needed or desired.

Findings from the qualitative interviews conducted in the baseline and post-alert periods included the following:

- In the baseline period the operators reported they would like to have more frequent weather updates. They also said they lacked adequate weather readings for some important locations in the valley.
- In both the before and after periods, operators expressed less than high confidence in the quality and accuracy of the weather data they were receiving in the RTMC. They uniformly said it was critical to confirm either data from sensors with human observations or readings from other sensors, or human observations with sensor readings. This follows management guidance that all weather data be verified with one or more additional sources before making a decision to post a travel advisory message. They did, however, perceive that sensor data quality had improved over this period.
- Operators in both periods felt that operating procedures and guidelines for making decisions based on reported weather conditions were less than adequate. Some said they desired additional training and consistent information on how to respond to the weather data (observations and forecasts) that they receive in the RTMC. Other experienced operators felt they knew how best to perform their job responsibilities without need for additional management oversight.
- RTMC operators want to be proactive with regard to weather. They want to be aware of impending weather conditions likely to affect traffic in advance if possible so that they are well prepared to respond in an appropriate and timely way. However, they feel that in practice they tend to primarily be reactive to weather, and as long as they receive the information they need in a clear and timely way, they respond appropriately.
- In the baseline period the operations floor was staffed most of the time with two operators who then could share the workload. In the later period after furloughs and staff reductions, there was typically only one operator. This meant responses to weather events had to take second priority to higher priority safety matters, and there would be response delays due to very busy shift activity.
- The operators valued the warnings and alerts that were available to them in the post-implementation period, though they felt it necessary to verify their accuracy before taking any actions based on them. They said the automated alert system has made them more aware and allowed them to be more responsive to events as they unfold.

Several lessons can be drawn from this evaluation of the experience of the Caltrans District 3 RTMC and their efforts to establish and refine an automated weather alert notification system. What has been learned, and continues to be learned, as this system matures and becomes more a part of the operating procedures of the RTMC, can be helpful to both Caltrans and other TMCs across the country as they explore ways to integrate weather information into their operations. These lessons include the following:

- **Operator training is essential for successful weather integration.** Both the RTMC management and the operators recognized the importance of training to help assure a well informed and consistent use of the new weather alert notification system. Providing this training to all the operators as a group has been a challenge in the face of the recent staff reductions and furlough policy enacted by the State of California. The training content should include clear operational policy guidance along with conveying to the operators an understanding of the system upgrades and changes, how and why they have been made, and how these affect the weather information flowing into the RTMC. A challenge is to strike an appropriate balance between the level of specificity in operational guidance for taking action in response to weather, and providing flexibility for the operators to use their experience and judgment in making decisions about their advisory and control actions.
- **Alert notification procedures need to be clearly and consistently specified.** It is important that the thresholds for issuing warnings and alerts that are programmed into the notification system be consistent with the specifications communicated to operators in the written procedures and training jnstructions, and that the operators understand and follow these procedures. The Caltrans District 3 procedures call for operators to verify an alert with information from adjacent RWIS sensors, available third party weather services (NWS, AccuWeather, local weather reports, etc.), and/or field observers (typically CHP, sometimes general public calling in). Reconciling differences among these information sources about a particular weather event condition takes experience and judgment on the part of operators. Procedures and training must account for the complexity of operator decision making based on information of varying accuracy, reliability and geographic focus.
- **A successful demonstration of an alert system depends on a well-integrated system.** The Caltrans District 3 system is built off of their existing SCAN Web software that monitors data from RWIS sensors and can be programmed to issue warnings and alerts when pre-defined weather condition thresholds are reached. The success of this system depends on accurate and reliable weather data from the sensors, appropriately defined threshold conditions, clear communications of alerts to the operators, procedures in place that guide operator responses, and operator training and buy-in to assure effective use of the information. The RTMC management has remained flexible and responsive throughout this demonstration period to understand where their alert notification system could be fine-tuned and improved as they experienced its use under various weather events. This has provided a foundational experience upon which they can consider a more robust alert system for the future that adds features and capabilities that are not currently available with existing hardware and software. For example, adding new strategically located sensors, upgrading the weather detection capabilities of the sensors, adding better detection and notification of the end of a weather event, adding possible visual and auditory notification in the RTMC, and refining their procedures, are all candidate improvements that have been identified in the course of operating the current system through this weather integration demonstration.
- **Time and resource constraints affect the performance of an alert notification system.** The State of California is experiencing a severe economic downturn that has resulted in reduced staffing and furloughs among TMC management and operators. This has raised the stresses associated with getting the day-to-day work done and made it more difficult to integrate the weather alert notification system into TMC operations. Operators have competing priorities and fewer staff to meet these responsibilities. Management faces similar constraints, resulting is less time to focus on new weather integration initiatives such as the alert notification system. TMC management also is constrained by time consuming procedural requirements of Caltrans associated with the implementation of new projects.

> These kinds of constraints need to be anticipated and understood when implementing new systems like this and contingency plans developed to overcome the constraints. There were several planned activities that were not accomplished due to funding or time constraints, including installing new RWIS sites and developing a more sophisticated alert system with enhanced capabilities. Based on the progress made to date, the RTMC management intends to improve their alert system as new funding can be secured.

In implementing the weather alert notification system, management developed a good step-by-step implementation plan that has guided them through the process. A critical task early in this process was to engage a contractor to calibrate the RTMC's field sensors. In the baseline period the operators reported having very little confidence in the data they were receiving from the sensors. After sensor recalibration and implementation of the alert notification system, operator confidence improved, though there remained some carryover of the perception that these data were still suspect. Operator training can help overcome such skepticism by explaining clearly what has been done to improve the data quality in the system and providing evidence that shows these improvements.

The use of the TMC logs offers a good example of how operators are learning to work with the alert notification system. The new procedures have emphasized the importance of making log entries that document and explain the actions operators have taken in response to receipt of the alerts, and the operators' logging performance has improved over this period. RTMC management also has made good progress implementing this system and responding in real time to the need for mid-course adjustments, refinement of procedures, and oversight of the operators. The evaluation process has served to identify ways the notification system, and the institutional support for the system, could be refined, and the result of this collaborative interaction with the RTMC is reflected in the benefits being derived from the alert notification system. Ultimately, it is the traveling public that is the beneficiary of these RTMC system innovations in terms of enhanced mobility and safety during periods of inclement weather and dangerous road conditions.

5.0 Strategic Marketing Plan

As a generalization, weather integration is currently at a relatively low level in most TMCs across the country. In many TMCs it is nonexistent at this time, even though weather, in some form, is affecting transportation safety and mobility everywhere. In addition to the technical tasks that involve working with a small set of TMCs, the strategic marketing efforts focused on activities aimed at increasing the awareness and capabilities of TMCs for integrating weather information in their daily operations.

5.1 Approach

Effective marketing helps TMC operators recognize the importance of road weather information in their operations, understand and use available tools to assist them in better managing weather-related events, and proactively seek out and access other resources in support of more effectively interpreting weather phenomena in the context of their transportation mission. Ultimately, the RWMP's goal is that TMC managers and operators fully embrace a culture that proactively uses new technologies and strategies for dealing with inclement weather.

A strategic marketing plan was developed as part of this task. The plan identified the primary and secondary audiences, the key messages to be conveyed, the challenges to be overcome, and the benefits of weather information integration. The plan also contained an itemized list of activities that supported the marketing efforts. Over the course of the project, various activities were conducted based on the plan.

5.2 Audience for Marketing

The primary audiences to reach via marketing efforts are the state DOTs and their statewide and local TMCs. TMC managers, operators, and staff are the primary audience for the Guide. TMC staff include individuals involved in weather-related activities such as maintenance and public safety. The secondary audiences include:

- Operations staff at FHWA Division Offices and Resource Centers. These operations staff need to be aware of the Guide so they can promote it and help the agencies they serve implement it.
- State DOT executive management, including senior State DOT traffic and maintenance managers. These managers need to be informed about the benefits of weather integration, as they can allocate resources and control the budgets at TMCs.
- Private consultants. Most TMCs and state agencies engage consulting services. Private consultants need to see the value in using the Guide to help the TMCs structure their planning efforts. Alternatively, TMCs may also want to use consultants to support them in their self-evaluation, planning and implementation activities.

- Weather information service providers. Providers of weather information are a secondary audience for the Guide as they can provide input to the integration strategies and planning portions of the Guide.

5.3 Marketing Activities Conducted

Over the past two years, a variety of marketing activities guided by the plan have taken place. Primarily these have involved presenting at conferences and stakeholder meetings. A webinar on Weather Integration was held through the National Transportation Operations Coalition web-forum and was attended by 100 transportation professionals. The electronic version of the Guide was downloaded over 30 times after the webinar. Table 21describes the various marketing activities that were completed in the past year.

Table 21. Weather Integration Marketing Activities Conducted during Phase III

Product	Description/Locations	Status	Start	Complete	Responsible Team Members
Flyer 2-page description of Guide	RWMP Website	Completed/ Updated	Oct-08/Mar-11	Nov-08/Mar-11	Cluett/ Gopalakrishna
PowerPoint Presentations Presentations on the Guide, use, results of self-evaluation and planning process	TMC Pooled Fund meeting (Nashville, TN, 2008)	Presented	Jul-08	Jul-08	Cluett
	TMC Pooled Fund Meeting (Nevada, July 2009)	Presented	Jul-09	Jul-09	Jimmy Chu
	ITE Technical Meeting (August 2008)	Presented	August 20, 2009	August 20, 2009	Alfelor
	ITS America Annual Meeting (2009)	Presented	Jun-09	Jun-09	Alfelor
	ITE Annual Meeting (2009)	Abstract Not Selected	Aug-08	Aug-08	Cluett
	Clarus/MDSS Stakeholder Meetings (August 2009)	Presented	Sep-09	Sep-09	Cluett
	Rural ITS Conference (August 2009)	Presented	Aug-25-2009	Aug-25-2009	Kitchener
	TRB Annual Meeting (January 2010)	Presented	Jan-10	Jan-10	Cluett/ Gopalakrishna
	ITS Heartland Annual Meeting 2010, Omaha, NE	Presented	March-30	March-30	Nancy Powell KC Scout
	ITS America Annual Meeting (2010) ITS Surface Transportation Weather Committee Meeting - (Houston, TX)	Presented	May-10	May-10	Cluett

Product	Description/Locations	Status	Start	Complete	Responsible Team Members
	Clarus/MDSS Stakeholder Meetings 2010 (Indianapolis)	Presented	Sep-10	Sep-10	Cluett/Powell (Battelle/KC Scout)
Webinar Describing the self-evaluation Guide development and process along with presentations from TMCs who have completed the self-evaluation	National Transportation Operations Coalition (NTOC)	Completed (98 attendees)	Aug-6-2009	Aug-6-2009	Battelle Team
Guide Availability Announcement Short paragraph in electronic newsletters and websites indicating availability of Guide on the RWMP website	RWMP website	Ongoing	May-09	Ongoing	
Short Articles 2-3 page articles describing the evolution of the self-evaluation Guide, the steps involved in self-evaluation, experiences of the TMCs involved, case studies and success stories, and next steps for weather integration	Public Roads (Printed)	Completed	Jun-10	Dec-10	Roemer Alfelor and David Yang
Other activities Tracking downloads of the Guide and following up with downloaders for Guide feedback	Roemer sent email to everyone who visited the Guide website at FHWA. Battelle followed up with the only respondent, WSDOT	Open ended	17-May 10		Roemer Alfelor and Battelle team

5.4 Results of Marketing Approach

Overall, the marketing approach resulted in a broad dissemination of the concepts of weather information integration and shared the experiences of the various TMCs engaged in this project. Quantitative numbers are difficult to track and in some cases may be realized only at a later date. The outputs of the marketing and outreach effort identified to date include the following:

- There were over 70 downloads of the Guide following the webinar held on August 6, 2009. Of the 70 downloads, 37 of these were from MPOs, TMCs or state DOTs in the country. The remainder of the downloads were from private consultants, universities, and non-US entities. Only one state DOT representative responded to an inquiry sent to all those who visited the Guide website and left contact information. Additional follow-up is needed to understand whether other TMCs may have conducted self-evaluations and implementation of integration strategies.
- Over 10 presentations were made at various conferences and stakeholder groups on the project by team members and FHWA.
- A Public Roads article published in January 2011 for managing traffic operations during adverse weather events (authored by Roemer Alfelor and David Yang of FHWA) contained a subsection on weather information integration drawing upon results of this study.
- Over 23 TMCs were contacted as part of this study to participate in self-evaluation efforts, and the final participants were selected from that initial list of contacted TMCs.
- A total of six (6) agencies have completed the self-evaluation process. All but one of them have developed integration plans.
- Four (4) TMCs (Sacramento, Kansas City, Wyoming, Colorado Springs) are starting to implement their integration plans/strategies.
- Wyoming TMC and Kansas City Scout have made presentations to other peer groups (ITS Heartland, *Clarus*/Maintenance Decision Support System (MDSS) stakeholder groups) about the benefits of weather information integration and the self-evaluation process.

5.5 Challenges in Marketing Weather Information Integration

Ongoing marketing activities for the weather information integration will likely have to overcome a number of challenges. These include challenges associated with TMC willingness to consider weather integration, to invest in the effort required to make integration successful, and to understand and use the Guide effectively. Recognizing these challenges and preparing to overcome them will be essential to a successful marketing effort. The main challenges and some approaches to overcoming them are outlined below:

- *Lack of interest in weather integration.* This may be due to a lack of awareness or understanding of data, services and technologies now becoming available that can support weather integration and contribute to more effective operational decisions. Many TMCs have said they “have what they need in terms of weather information” and are unaware of the immense opportunity offered by new weather information sources for traffic management. Continued championing of the cause of weather integration by the RWMP coupled with peer to peer exchanges can greatly increase interest in this topic. Repeated presentations by TMC managers about the success of weather integration offer a powerful way to build awareness and acceptance, and bring this concept into operations.

- *Lack of staff and budget resources to support planning for future integration.* TMC operators and staff are already exceedingly busy and are reluctant to take on more responsibilities. It will be essential to demonstrate that integration is cost-effective and can lead to work efficiencies. As the experiences with the Guide revealed, weather information integration does not need to be expensive. Most of the TMCs were able to identify immediate and low cost actions to increase the role of weather information in decision-making for their TMC.
- *Too many barriers to implementation of recommended strategies.* This may include lack of budget to implement, lack of support from upper management, or insurmountable issues with their IT departments. The current fiscal environment makes it difficult to promote new ways of operating. Agencies want to see evidence that the benefits significantly exceed likely costs before committing even to planning for new technologies or procedures. Again, success stories and peer to peer exchanges will be critical in overcoming some of these barriers.
- *Reluctance to change operational procedures.* Organizations with long-standing procedures that work well for them are resistant to making changes, and effective integration usually implies new organizational procedures, responsibilities, staff roles, and interactions with other entities. The use of the Guide and the consensus-building nature of the tool can help overcome the reluctance to change operational procedures. For example, in Colorado Springs the weather integration planning meetings resulted in Colorado DOT and the city sharing a weather information resource about which the city had been unaware.
- *Traffic operation is traditionally reactive.* Effective weather integration implies a proactive posture toward traffic management and operations that takes account of advanced information on impending weather conditions and likely impacts on the transportation system. Changing a predominantly reactive culture to a more proactive approach will be difficult. Good examples of proactive operations, informed by weather information, and coupled with time to develop and become comfortable with new procedures will help move this forward.
- *Reluctance to "think outside the box."* It is difficult for TMC operators and managers to imagine the gaps in their operational functions or what new functions might be possible given enhanced weather integration. Effective marketing needs to paint a clear picture of the operational possibilities along with the benefits of integration.
- *The self-evaluation and planning process appears too complex.* TMCs may feel that the Guide will not fit their special circumstances. The challenge is to market the Guide as a process that can be implemented by any TMC and tailored to their special needs. Resources are available to assist TMCs with a process that is sensitive to the many differences and unique aspects of TMCs across the country. A feedback process is part of the Guide, and suggestions for improvement are encouraged. The Guide is being continuously improved in response to user experiences.

6.0 Refinement of the Self-Evaluation and Planning Guide

The development of the self-evaluation and planning guide was a cornerstone of the weather information integration project. The Guide, as described in the previous sections, is a standalone Microsoft Access database application with a companion written document version. This section provides feedback from the TMCs on the Guide and presents options for further refinement and updates of the Guide.

6.1 Feedback and Changes Suggested by Users of the Guide

The TMC representatives who participated in this project appreciated the thoroughness of the Guide content, clarity of instructions, and the applicability of the integration strategies presented. Specific feedback was requested and obtained based on the use of the electronic version of the tool. The Guide was updated and improved based on the suggestions from the users. Table 22 provides a tabular summary of the changes requested by the TMCs and the changes implemented in the Guide.

Table 22. Changes to the Guide Based on User Feedback

Reason for Suggested Change to the Guide	Description of Change Implemented
Need header and footer in reports that users can print out based on user inputs. This will help when TMCs are printing multiple Guide section reports for multiple regions (such as in Louisiana) or having individuals fill out the Guide separately and then print it.	Added a form at the beginning of the Guide to allow users to enter the following: • Created By • TMC Name • Region of Interest • The information is included as the page footer in all the reports created.
Need additional sections in the Guide after Section 6. Currently, the TMCs get through the self-evaluation process and find themselves overwhelmed by the number of strategies presented to them. Need a structure that allows TMCs to further prioritize and narrow the set of strategies that they want to carry forward.	• This required restricting the content of Section 6. The text in the introduction section was simplified with an emphasis on the TMCs printing the reports, reviewing as a group, and testing some “what-if” scenarios. • Once the TMC has reviewed the report, the user is directed to a new sub-form with the list of strategies that they have previously selected in Section 5. The TMC can prioritize these strategies for immediate or future implementation. Two new reports were created with user-selected strategies identifying immediate implementation and future implementation.

Reason for Suggested Change to the Guide	Description of Change Implemented
Comment in Section 1: TMCs were confused about the terms "Area-wide" and "Region-wide". This confusion needs to be resolved.	• Changed "Area-Wide" to "Corridor-Specific" to be consistent with the paper version of the Guide.
Comment from a TMC in Section 2 (Question 2.1): Not clear what "Traffic Mgmt Device Impairment" means. Not clear what "Increased use of equipment/labor" means, especially compared to the next choice "increased use of in-house labor"	• Changed the wording to "Traffic Control Device Malfunction (Signals, DMS, etc.)" as recommended by the TMC. • Changed the wording to "Increased use of equipment/materials" and removed the word labor, as it was covered in the other choices.
Comment in Section 3: Does not have update button Section 4 button is next to Section 3 "Next Question" which is confusing Question 3.4 – Rephrase slightly to make clear Current Status – Default. Have the check-box uncheck itself.	• Changed the text to "Update and Move to Section 4" • Moved the Section 4 button below and created a separator between the "Next question" and Section 4 • Cannot change this element in the Guide due to the structure of the underlying table and error checking requirements
Comments on Reports: Check formatting of all reports Word or PDF versions are suitable Create new report in Section 6 with a subset of strategies that a TMC is interested in with a sense of priority.	• Checked, and revised as needed, formatting of all reports • Office 2007 includes the ability to save the files as PDF • Enhancements needed to be able to export to Microsoft Word were investigated but determined to be not easily programmable in Microsoft Access at this time. • Section 6 changes described earlier in the table
Comments on Section 7: The Guide stops abruptly and the outline is too complex. Integration Plan outline needs to be revised based on experiences with TMCs	• Changed the text in the Section 7 form to clearly articulate the purpose of the weather information integration plan. • Created a new outline for the TMCs to follow based on the previous TMCs' experiences.
Editorial: Spell out all acronyms in all the strategy descriptions Check for typos	• Went through the Guide and spelled out acronyms and fixed typos, especially for Section 3 and Section 4

The Guide was updated in June 2010 with the changes as indicated in the table above. The corresponding document version of the Guide was likewise updated. No further changes have been suggested by the TMC users.

6.2 Updating the Guide

The self-evaluation Guide has been successfully used at all the TMCs participating in this study. For an ad-hoc electronic tool designed on the fly to support the complexities of weather integration, the Guide has held up remarkably well to the variety of TMCs and their varying needs. However, it is important to realize that the Guide needs to be continuously updated as the field of weather information evolves, new technologies are developed to support weather integration, and TMCs expand their needs and vision of how to more effectively integrate weather information into their daily operations.

Technically, the Guide needs a periodic update of the Weather Information Integration Strategies and User Needs. Currently, there are 11 items of integration and 5 levels for each item. These were developed to cover the gamut of information integration options in 2008. With improving technologies and capabilities within TMCs, these strategies need to be reviewed and updated. Similarly, the user needs should be reviewed and updated to reflect the current desires of TMCs.

From a usability standpoint, major additional improvements to the Guide are limited by Microsoft Access' capabilities. TMCs have requested several usability updates that are better suited to other platforms than Microsoft Access. For example, the following suggestions identified by the TMCs would be useful but either too costly or not possible to implement in Microsoft Access:

- Translating the stand-alone application to a web-based tool will greatly enhance ease of access and repeated use of the Guide.
- Enhanced querying and what-if capabilities to understand the implications of implementing a particular user need
- Enhanced reporting capabilities, including creating reports in Microsoft Word
- Linkages to other RWMP programs and projects

7.0 Accomplishments and Lessons

The accomplishments of many of these TMCs toward the implementation of selected integration strategies are noteworthy and reflect management's recognition of the critical importance of weather to their operations and a strong motivation to better position their operations to take advantage of improved access to weather information.

7.1 Accomplishments and Outcomes

All these TMCs can point to a common set of important accomplishments achieved through their participation in the weather information integration program, as follows.

- Four comprehensive weather integration plans were prepared that serve not only to guide each TMCs future integration implementation efforts but also to offer clear examples for the benefit of other TMCs of weather integration across a range of strategies and under varying conditions.
- Each TMC established, through participation in the weather integration process, new partnerships, both internal and external to their agency that served to enhance their overall operations, provide benefit to the traveling public, and chart a pathway to improved working relationships in the future.
- TMCs acknowledged the importance of working closely with their counterparts in maintenance. Stronger relationships were established that will encourage collaborative activities and foster active sharing of weather information.
- Awareness was raised at all levels of the DOT organizations involved, from TMC floor operators and field staff to upper management, of the potential role and value of weather information to enhance the quality and content of traffic operations, and the value of a more proactive stance with regard to managing their systems before, during and after weather events.

Specific accomplishments to each of the TMCs engaged in Phase III are summarized in Table 23.

Table 23. Summary of Accomplishments and Outcome Achievement among TMCs

Implementation Accomplishments	Anticipated Outcomes and Benefits
Phase II Site: Sacramento RTMC	
Based on the self-evaluation process and recognizing the need for quality RWIS weather data, the RTMC recalibrated their RWIS equipment.	• Increased operator confidence in the quality and accuracy of weather information coming from their RWIS stations.
Established an initial automated weather alert notification system.	• As operators became more familiar with the alert system, the timing of message posting improved (i.e., messages were posted for higher percentages of time during event occurrence).

Implementation Accomplishments	Anticipated Outcomes and Benefits
Established policy guidance for operators regarding which DMS to use for alerts coming from various RWIS locations.	• Message posting better tracked the policy guidance over time, leading to more messages posted on appropriate DMS during weather events than before implementation.
Management awareness increased regarding the importance of providing operator training.	• Training for operators increased, leading to greater operator understanding of the value of the alert system and the importance of consistent adherence to messaging policy.
Management learned how to fine tune the threshold and interval settings for the weather alerts.	• Properly set thresholds yielded warnings and alerts that more accurately reflected actual weather conditions in the field • Properly set alert intervals reduced the irritation to operators of receiving too many unnecessary warnings and alerts while assuring that the warnings and alerts that were issued were appropriate.
Experience with this initial alert system provided a foundation upon which management understood the need and value of improvements to their system.	• The RTMC has very limited resources under the current economic conditions, but when resource availability improves, the RTMC intends to implement a new, expanded alert notification system. • Overall, operator confidence in making proactive weather-based notifications to the traveling public has increased.
Phase III, Tier 1: Kansas City Scout TMC	
Demonstrated advance notification of approaching weather events and presented through ATMS to operators as on-screen geo-located polygons.	• Will guide the full integration of this capability within their ATMS. • Enhanced operator awareness and preparedness to manage weather event information • Timely issuance of weather advisory messages to the traveling public • Enhanced traveler safety and mobility
Facilitated improved working relationships between TMC operations and maintenance	• Maintenance representatives sit in the TMC at the “snow desk” during weather events and are able to maintain continuous radio communication with their trucks and plows and provide real time updates via MoDOT’s Winter Weather Event database. • TMC operators and the maintenance representatives in the TMC actively share weather information through the ATMS and both have direct access to the CCTV images of changing road conditions.
Compiled all possible weather data sources for future integration into their ATMS.	• Weather information ready for ATMS integration. • Highly efficient TMC operations, with an ATMS that “pushes” weather data to the desktop, versus an operator having to “pull” in weather data. • Enhanced advisory weather notifications to MoDOT and KDOT maintenance departments. • DOT maintenance, partners, and public satisfied with TMC performance with regard to weather information management • Better cross-agency and departmental communication and coordination. • Proactive regional weather coordination for widespread, multi-state events. • Ability to assess post-event data and identify trends, enabling new decision-making criteria for the TMC, its partners, and the traveling public.

Implementation Accomplishments	Anticipated Outcomes and Benefits
Identified threshold levels for severe weather event triggers, allowing automated road segment specific weather condition alerts within their ATMS.	• Future ATMS integration will utilize these thresholds to develop alert system. • Efficient and timely assignment of motorist assist and emergency response resources to problem areas. • Timely weather event creation and posting advisory messages. • Timely and updated incident reporting and travel times posted to message signs. • Timely on-scene response to weather incidents resulting in improved clearance times. • Enhanced safety and mobility for maintenance crews and the traveling public.
Assessment of localized weather conditions by expert meteorologists in real time.	• Improved interval assessment for start and end times of weather events. • Efficient allocation of available resources during weather events. • Potential for cost savings (staff time, materials, resources) and enhanced ability to modify staffing resources for anticipated weather events.
Approach developed to incorporate check boxes within ATMS for operators to provide timely reporting of weather event responses.	• Approach will be included in future ATMS integration activity. • Immediate post-event assessments of TMC efficiency and effectiveness. • Improved public relations with partners and motorists during severe weather events. • Enhanced agency and public satisfaction.
Phase III, Tier 1: Colorado Springs TMC	
Identified new sources of weather information through contacts fostered with CDOT during the self-evaluation process.	• CSTMC now receiving daily weather updates from the same source that has been used by CDOT but about which CSTMC had been unaware prior to the weather integration planning meetings.
The process of identifying the weather information integration strategies and tasks has led to refinements in CSTMC's Concept of Operations and operating procedures related to weather	• Awareness of the value of weather information and new ways to put that information to use in the CSTMC operations center has increased.
Established a plan and schedule for a pilot test of a signal timing plan, guided by weather information, in one of 16 city grid sections.	• Demonstrate the effectiveness of a weather-responsive signal timing plan, and based on the pilot test results, extend to all districts in the CSTMC jurisdiction. • Reduce the risk of intersection crashes and fatalities during adverse weather conditions. • Increase the throughput in corridors covered by the new signal timing plan during adverse weather conditions.
Phase III, Tier 1: Louisiana Statewide TMC	
Working through the Guide made the LATMC aware of the value of identifying and integrating into TMC operations all available weather information sources, such as MAP, State Police, and LSU (their RWIS).	• When completed according to their plan, a weather information coordinator will be appointed, thereby facilitating a more proactive use of all available weather information to better manage traffic and inform the traveling public.

Implementation Accomplishments	Anticipated Outcomes and Benefits
Awareness of the need to standardize policies and procedures to guide the flow of weather information and define weather advisory thresholds.	• When completed according to their plan, these actions will help assure a consistent operational response to weather conditions throughout the state (across the multiple TMCs).
Prepared a strategy for overcoming DOTD's reluctance to purchase new RWIS equipment that involves a small scale pilot test demonstration of the value of these systems.	• This pilot test, if implemented as planned (requires obtaining funding for the test equipment), can demonstrate RWIS benefits exceed costs, especially in high weather risk locations such as the Atchafalaya Bridge, Bonne Carre Bridge, and Red River Bridge locations that are subject to severe fog events.
Phase III, Tier 2: Wyoming Statewide TMC	
Expanding RWIS coverage throughout state, and multiple corridor RWIS projects.	• Improved access to weather information.
Expanding vehicle weather data transmission to TMC from plows with AVL/MDC.	• WYDOT expects challenges because the MDC component lacks a clear implementation strategy and integration with WYDOT's AVL system.
Employed a part time, contracted meteorologist as the TMC weather information manager.	• Assist TMC operators with professional interpretation of weather information and relevance to operational decisions.
Add VSL in four locations and continue to expand in statewide corridors.	• Expanded weather information integration will support extension and operation of WYDOT's VSL program.
Expand and enhance the weather alert notification system in phases.	• This activity is expected to start this year, 2011, and will improve operational response to emerging weather conditions and provide timely notification to the traveling public.
Expand decision support tools, starting with VSL and moving to DMS recommendations.	• This activity is expected to start this year, 2011, and will facilitate timely and effective decision making for TMC operations.

7.2 Lessons Learned

A review of the accomplishments achieved so far by the TMCs that have participated in the weather information integration program over the past six years illustrates a number of "success factors," lessons, and remaining challenges based on these experiences that can be expected to be relevant for any TMC. Various lessons learned have been listed in the prior reports on the earlier phases of this project, and more recently based on the Sacramento RTMC implementation and evaluation of their weather alert notification system (see Section 4). The potential value of lessons from these experiences is tied to creating a wider awareness of the benefits of weather integration and engagement in a process to identify and deploy integration strategies that can improve the operations of TMCs across the country. The ultimate benefits of weather integration are the attainment of the goals of safety, mobility, and satisfaction for the traveling public. Broad lessons, common across each of the TMCs in this study, include the following:

- TMC managers are not generally predisposed to seek out new ways to integrate weather information into their traffic operations, and often they are unaware of weather resources that exist within their broader agency. After participating in the self-evaluation and integration planning process, the TMCs in this study recognized the potential value offered by weather integration, but for the most part required considerable assistance in moving forward to incorporate new ways to integrate weather. Self-motivation sufficient to support achievement of real changes in operations based on weather integration, along with a clear understanding of the steps they needed to take, appears to be rare.

- Resources, both financial and staff, constitute a serious challenge to the successful promotion of weather integration in TMCs. While this point has been made a number of times before, it deserves repeating. This is not just a temporary problem associated with particularly difficult economic conditions in many states. TMC personnel are so stretched to fulfill their daily obligations and tasks, that motivating them to take on a new set of tasks and responsibilities, including modifying policies and procedures to support new ways of operating with weather information, is very difficult. Although TMC managers and operators may agree that enhanced weather integration could help them better meet their operational needs and serve their traveling public, weather integration simply doesn't represent a high enough priority for them among their many tasks.
- While the weather integration project has focused on enhancing TMC operations, the process depends on teamwork not only within the TMC but also with other agencies and stakeholders. Many, though not all, TMCs have separate structures for their operations and maintenance components. The most effective weather integration implies a seamless sharing of information and decision making across operations and maintenance, but the historical arrangements in TMCs often present major institutional and cultural barriers that hinder information sharing. Engagement in the weather information integration project has helped overcome these barriers where they have existed, but the motivation for TMCs and State DOTs to make that happen is lacking.

In spite of many challenges, the TMCs that have been engaged in the integration project have achieved notable progress, as shown in Table 23 and discussed throughout this report. However, in order to successfully promote and achieve more widespread TMC engagement and accomplishment with weather information integration, a number of additional steps should be considered, as recommended in Section 8.

8.0 Recommendations

This section identifies specific recommendations that define a roadmap (next steps) to continue the efforts of the RWMP to promote and enhance the level of weather information integration in the nation's TMCs. These recommendations focus on the need to build a sustainable weather integration program, effectively promote a weather information integration program with documented benefits, refine and maintain a comprehensive tool to evaluate weather information integration in a particular TMC, and identify the most technologically advanced strategies to enhance their capabilities.

Specific recommendations include:

1. Assure Progress and Sustainability of Weather Integration
2. Identify and Document Evidence of Weather Integration Benefits
3. Assure Currency and Relevance of Weather Integration
4. Refine Self-Evaluation Process and Improve Tool

Each recommendation describes the objective, rationale, approach, and outcome – providing the details to understand its importance and significance to increase the breadth of the weather information integration initiative. Identified within each recommendation is a set of activities or tasks necessary to achieve the overall objective of the recommendation. Although the recommendations are not in a priority order, there is high degree of interaction among the recommendations. Outcomes of a particular recommendation may help to inform other recommendations. For instance, the identification and documentation of weather integration benefits (for a variety of strategies) would certainly support efforts to promote the initiative's goals with TMCs that may be considering implementing weather information integration.

8.1 Recommendation 1: Assure Progress and Sustainability of Weather Integration

Objective: A goal of the RWMP is to encourage widespread awareness of the value of integrating weather information and systems into TMC operations and progress toward accomplishing that, resulting in a high degree of weather information usage in system operations and management.

Rationale: The TMC Weather Integration project has shown that significant potential exists to improve weather information integration at TMCs. Recent advances in the availability of information and improvement in traffic management approaches and technologies significantly improve the ability to achieve weather responsive traffic management (WRTM). As champions emerge on behalf of TMC weather integration, there needs to be a focused push to enhance TMCs' understanding of potential weather information integration opportunities and how they fit under the larger umbrella of WRTM. Even those TMCs that have made some headway with weather integration have difficulty visualizing the benefits of additional investments, and virtually all TMCs operate under very constrained budgets and difficult economic environments. State DOT and TMC managements want and expect clear evidence of a strong benefit-cost tradeoff before they will authorize capital investments to implement weather integration initiatives. The motivation among TMCs to pursue weather integration in the absence of on-going outside assistance is insufficient to overcome the financial hurdles and knowledge gap that hinder significant advancements in this regard. Reaching the RWMP goal without putting in place a sustainable strategy to support weather integration is going to be very difficult.

Approach: This recommendation is grounded in experience working with some of the more advanced, progressive TMCs with regard to their recognition of the importance of weather in their operations. Long-term progress incorporating weather integration into TMC operations must be grounded in a motivated TMC constituency that understands the role of weather integration in the context of WRTM, and not allowed to remain dependent on continued outside assistance. This can be achieved by a multi-pronged strategy that includes the following elements:

- Follow-up actively on the marketing strategies identified in the current program. This includes updating flyers and disseminating testimonials from TMCs that have successfully integrated weather information, and having them convince their peers from firsthand experience. Expand a database of success stories that demonstrate how weather integration has enhanced operations and provide implementation details.
- The RWMP should present weather integration as a key component of WRTM, emphasizing how weather information integration dovetails with the other key elements of the WRTM program (illustrated in Figure 1).
- Develop and actively support an institutional strategy within the RWMP to respond to TMC questions and needs with regard to weather integration. Offer training and support to the self-evaluation and integration planning process. Encourage the creation of a new working group of TMC representatives, and sponsor annual or more frequent meetings of this group that would focus on all aspects of weather integration (needs and strategy identification; integration planning; implementation approaches; performance evaluation).
- Sponsor one or more workshops with representation from all stakeholders (TMC operations and maintenance; emergency management agencies; software developers; meteorologists; etc.). Include leading weather integrators who can speak from successes.
- Work closely with and provide support to organizations or groups that include members of the TMC community or work with TMCs, such as the TMC Pooled Fund Program, the TRB, the Institute of Transportation Engineers (ITE), and the American Association of State Highway and Transportation Officials (AASHTO) and their committees and subcommittees that focus on operations and maintenance. Make presentations to these groups based on successful weather integration experiences, encourage them to focus on weather integration, and make them a part of an institutional strategy for sustainable support of weather integration.
- In the short run, actively support TMCs that express an interest in weather integration, but seek to replace such *ad hoc* responses with an institutionalized, sustainable support infrastructure.
- Engage each of the major new transportation initiatives to educate and promote with regard to weather integration and include their representatives in the new institutional mechanisms.
- Seek to overcome the traditional separation and communication barriers between TMC operations and maintenance. Encourage a proactive approach to weather integration that is open and sharing in its orientation and practice. Maintenance is currently better organized than operations, with their focus on winter pavement management issues. A good next step

would be to seek to include traffic operations in their network, meetings and conferences to seek common ground around enhanced weather information and integrated decision making.

Outcome: The outcome of this recommended set of activities would be a rapid increase of the number of TMCs that undertake weather integration activities in their operations and a growth in sophistication among TMCs that have already made some headway toward weather integration. Weather integration should become mostly self-supporting and no longer require on-going costly outside support in order to motivate adoption.

8.2 Recommendation 2: Identify and Document Evidence of Weather Integration Benefits

Objective: In order to successfully promote the weather information integration initiative and encourage TMCs to consider weather integration strategies to improve their operations, they need to better understand the potential benefits of implementing these strategies.

Rationale: Recent research has revealed very limited measurable benefits of weather information integration applications to traffic operations. The evaluation of the Caltrans D3 Sacramento Regional TMCs' weather alert system indicated how timely and accurate weather information could improve traveler information messaging. Although this analysis showed promising results, the alert system was limited and it only addressed one weather information integration strategy. Also, it addressed primarily better weather information coming into the TMC, but did not evaluate the actual integration of the weather information and how that might affect TMC operations. The RWMP needs a set of quantifiable benefits for a variety of strategies that can be shared with prospective TMCs interested in weather information integration acting as a catalyst to motivate them to perform a self-evaluation and move forward with implementation of weather integration strategies.

Approach: The completion of this project has resulted in three TMCs that are ready to implement various weather information integration strategies, as follows:

1. Kansas City Scout – newly assembled weather information integrated into their ATMS to alert operators and provide them with relevant weather information to make operational decisions.
2. Wyoming Statewide TMC – weather information integrated into variable speed limit system to better inform operators to assign appropriate speed limits depending on road weather conditions.
3. Colorado Springs TMC – weather information integrated in TMC to better assign traffic signal timing during snow and ice conditions. Currently conducting a pilot test on one signal grid area within the city involving a major arterial and feeder routes.

In addition, other TMCs may be advancing their weather information integration capabilities. This group may include TMCs that were originally contacted and whose experiences formed the basis for the current strategies in the Guide and those that have recently downloaded the Guide from the FHWA website.

This recommendation proposes to: 1) continue supporting the three TMCs listed above in implementing their respective weather information integration strategies and conducting an evaluation to identify and document evidence of weather integration outcomes and benefits, and 2) investigate other TMCs that also may be actively enhancing their weather information integration capabilities and assist them in evaluating and documenting their experiences. Specifically, this effort would:

- Assist Kansas City Scout to complete their evaluation plan (based on their most current implementation approach) and execute the plan by conducting an evaluation of their new weather integration system. This effort would provide quantifiable measures of the benefits of integrating weather information into a sophisticated ATMS system to alert operators, provide them with enhanced road weather information, and support their decision making.
- Work with the Wyoming Statewide TMC to prepare an evaluation plan (based on their weather integration implementation) and execute the plan by conducting an evaluation of their weather integration efforts. This activity would work closely with the University of Wyoming that is currently evaluating the variable speed limit system on I-80 in southern Wyoming. This effort would provide quantifiable measures of outcome benefits of integrating road weather information into their TMC to better inform operators and possibly automate their I-80 variable speed limit system.
- Assist the Colorado Springs TMC to complete the evaluation plan for their pilot test and execute the plan by conducting an evaluation of the weather responsive signal timing plans. This effort would provide quantifiable benefits of implementing snow and ice conditions signal timing plans.
- Investigate other TMCs that may be enhancing, or desiring to enhance, the integration of weather information in their TMCs. This activity would include contacting those that are known to have downloaded the Guide and determine their use of the Guide. This would also include contacting the original ten TMCs that formed the basis for the current state-of-the-practice in weather information integration. A short list of TMCs believed to have recently expanded their capabilities or planning to do so in the near future would be prepared.
- Assist the above short list of TMCs to complete an evaluation plan and then carry out an evaluation of their TMC weather information integration implementation. This effort would add to the benefits database developed by working with the first three TMCs as described above.
- Summarize the benefits realized through these proposed evaluations into a report and database that can be used by the RWMP and others to promote weather integration.

<u>Outcome</u>: The outcome of this recommendation will be a set of documented benefits (a report and database) attributable to the implementation of specific weather information integration strategies that could be used to promote and sustain the RWMP’s weather integration in traffic operations initiative.

8.3 Recommendation 3: Assure Currency and Relevance of Weather Integration

<u>Objective</u>: In order to encourage and assure the adoption of weather information integration strategies in TMC operations, the RWMP must facilitate the on-going evolution of integration strategies to “keep pace” with rapid technology and programmatic developments of direct interest to TMC traffic operations and management.

<u>Rationale</u>: Weather information integration as an RWMP initiative is unlikely to become routinely accepted and implemented in the nation’s TMCs if it is presented as a concept essentially detached from the major transportation program initiatives and new information management technologies

being introduced today and in the future. While TMCs for the most part understand the connections between road weather conditions, and system performance, traveler safety and mobility, they also need to understand how weather integration strategies fit in with and can be supported by the new technologies being introduced in state DOTs. Failure to maintain and promote weather integration that is fully consistent and integrated with the latest technologies and program initiatives can lead to reduced interest, adoption and deployment of potentially beneficial weather integration strategies.

Approach: An initial challenge is to clearly characterize how the USDOT's transportation initiatives can benefit from, as well as support, weather integration in TMC operations. A recommended approach is to prepare a white paper on "Relevance of Weather Information Integration to TMCs." This white paper would seek to incorporate the following elements:

- Describe advances in ATMS hardware and software that can accept and support improved processing and management of weather information. Clarify the data formats that optimize the utility of weather information, and describe the outputs that can most benefit traffic operations. Provide examples of effective uses of weather information in TMC operational settings utilizing current ATMS computer structures.
- Identify and describe the major current transportation program initiatives and how weather information serves as inputs to those programs along with how the programs can encourage and benefit weather integration strategies. The role of weather information integration needs to be examined in three major emerging programs – Active Transportation Demand Management (ATDM), Integrated Corridor Management (ICM), and the Connected Vehicle initiative. In each of these programs, RWMP should encourage increased understanding and use of weather information. For example, future ICM initiatives around the country should consider a weather-responsive scenario and the ATDM program could focus on linking active traffic management & travel demand management during adverse weather. The RWMP has already started engaging the Connected Vehicle community in considering vehicles not only as mobile observation platforms but also as receivers of customized spot-specific road weather information.
- The RWMP has stressed the importance and value of encouraging TMCs to become more proactive with regard to weather information and its integration into operations. However, TMCs have difficulty visualizing what it means to be proactive with weather. Traditionally, TMC operations has focused on traffic performance, and attended to weather only after they observe evidence that weather has affected traffic adversely. Does being more proactive suggest anything more than increasing preparedness for dealing with on-coming weather? Most TMCs are not willing or prepared to notify travelers about weather before it strikes or before there is evidence that it is impacting traffic flow or safety. The white paper should clarify in practical terms, using real examples, what it means to be proactive with regard to weather integration and how being more proactive offers benefits.
- This approach overlaps with the recommendation related to updating the tools used to support TMCs working through the self-evaluation, planning and implementation process for weather integration, and the recommendation related to more thoroughly understanding and communicating the benefits of weather integration. The weather integration initiative must be kept responsive and relevant to TMC operational needs.

Outcome: This recommendation emphasizes the importance of staying flexible and adjusting weather information integration strategies and rationale to keep current and relevant. Outcomes would include clear, practical examples of how weather integration fits in with the current and projected major transportation program initiatives (both supporting and benefiting from them). The recommended white paper will support further marketing and promotion of weather integration among TMCs by further clarifying its operational benefits.

8.4 Recommendation 4: Refine Self-Evaluation Process and Improve Tool

Objective: In order for TMCs to evaluate their current and future potential level of weather integration, they require a tool that is both easy to use and is up-to-date with the most current advances in weather integration strategies.

Rationale: The results of working with several TMCs (documented in this report) suggests that the current weather integration self-evaluation and planning guide (the tool) was extremely useful to assist them with identification of potential weather integration strategies based on their stated needs. However, they did offer suggestions for improvements to the guide to enhance usability, provide better interactive features, and improve the linkages between the needs, strategies and recommendations. Also, the TMCs had difficulty transitioning from selecting weather integration strategies to developing an integration/implementation plan – the consultant team assisted each of them to complete this task. Additionally, the consultant team noticed that all the TMCs got stuck in Section 5 of the guide not knowing how to proceed – they needed assistance at that point to complete the process. Their primary concern was how to select and prioritize the recommended strategies. It is essential that the RWMP's weather integration self-evaluation and planning process, and the related tool, be understandable, easy to use, technically sound and up-to-date with the most current information.

Approach: This recommendation focuses on refining and updating the weather integration self-evaluation and planning process, improving the tool's usability, and incorporating the most current technological advances in both (the process and the tool). Specifically, this effort will:

- Review and update the need statements to be more reflective of TMC desires to be more proactive with their responses to road weather conditions.
- Research and update the road weather integration strategies to reflect the most advanced practices being promoted by USDOT and implemented by state DOTs and TMCs. These incorporate the latest communication, programmatic and technological advances, reflect today's best practices, and support new program initiatives such as Connected Vehicles, ICM and ATDM. This may involve revising the weather integration strategy definitions and levels.
- Improve the matrix of needs to weather integration strategies based on the findings of the first two bullets.
- Review the complete weather integration self-evaluation and planning process as appropriate to possibly enhance and/or add elements such as how to describe a more iterative process, improve upon the implementation planning approach, and adding guidance on evaluating the benefits of the selected strategies for implementation.
- Revise the tool based on the above outcomes and host the tool on a new more flexible platform (an Internet-based product) to address some of the input received by the TMCs to improve its usability. The current Microsoft Access based tool has limitations that can not be overcome using this platform.

Outcome: The outcome of this recommendation will be a technically and programmatically up-to-date weather integration self-evaluation and planning process, and a more usable tool that TMCs can use to investigate and implement possible road weather integration strategies to improve their operations during inclement weather conditions.

8.5 Conclusion

This report has demonstrated significant progress toward the implementation of advanced levels of weather information integration strategies among many of the TMCs that participated in this study. They have important accomplishments to show for their efforts. The future holds great opportunity to extend the benefits of weather integration to many more TMCs across the country that face weather challenges in their daily traffic operations. This study presented some lessons from the experience of the past six years of this integration program that highlight the importance of strong self-motivation within TMCs to engage a team composed of operations, maintenance and related agency representatives in weather integration within an environment of constrained resources. The four recommendations presented are directed toward sustaining and enhancing the weather integration program, building additional evidence supporting the benefits of integration, and assuring that the support and tools available to TMCs to help them are effective and up-to-date.

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APPENDIX A. List of Acronyms

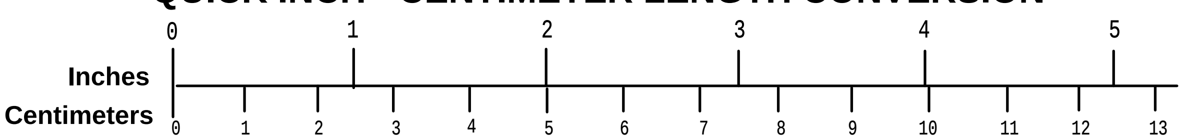
AADT	**Average Annual Daily Traffic**
AASHTO	**American Association of State Highway and Transportation Officials**
ATDM	**Active Transportation Demand Management**
ATMS	**Advanced Traffic Management System**
AVL	**Automated Vehicle Location**
CARS	**Condition Acquisition and Reporting System**
CCTV	**Closed Circuit Television**
CDOT	**Colorado Department of Transportation**
Clarus	**FHWA Road Weather Information Database**
CO	**Colorado**
CSP	**Colorado State Patrol**
CSPD	**Colorado Springs Police Department**
CSTMC	**Colorado Springs Traffic Management Center**
CTMC	**Colorado Statewide Transportation Management Center**
DMS	**Dynamic Message Sign**
DOT	**Department of Transportation**
DOTD	**Department of Transportation and Development**
DUI	**Driving Under Influence**
ECAR	**Enhanced Citizen-Assisted Reporting**
EOC	**Emergency Operations Center**
FHWA	**Federal Highway Administration**
GIS	**Geographic Information System**
Guide	**Weather Information Integration Self-Evaluation Guide**
HAR	**Highway Advisory Radio**
ICM	**Integrated Corridor Management**
ITE	**Institute of Transportation Engineers**
ITS	**Intelligent Transportation System**
KDOT	**Kansas Department of Transportation**
LOS	**Level of Service**
LSU	**Louisiana State University**
MA/ER	**Motorist Assist/Emergency Response**

MAP	**Motorist Assistance Patrol**
MDC	**Mobile Data Computer**
MoDOT	**Missouri Department of Transportation**
MOU	**Memorandum of Understanding**
NDFD	**National Digital Forecast Database**
NDOR	**Nebraska Department of Roads**
NOAA	**National Oceanic and Atmospheric Administration**
NWS	**National Weather Service**
O&M	**Operations and Maintenance**
POC	**Point of Contact**
RTMC	**Regional Transportation Management Center**
RWIS	**Road Weather Information System**
RWMP	**Road Weather Management Program**
SALECS	**State Law Enforcement Communications Systems**
SQL	**Structured Query Language**
TCS	**Traffic Control System**
TMC	**Transportation Management Center or Traffic Management Center**
USAFA	**U.S. Air Force Academy**
USDOT	**U.S. Department of Transportation**
VD	**Vehicle Detection**
VDS	**Vehicle Detection Stations**
VMS	**Variable Message Sign**
VSL	**Variable Speed Limit**
WRTM	**Weather Responsive Traffic Management**
WSDOT	**Washington State Department of Transportation**
WYDOT	**Wyoming Department of Transportation**
Wx	**Weather**

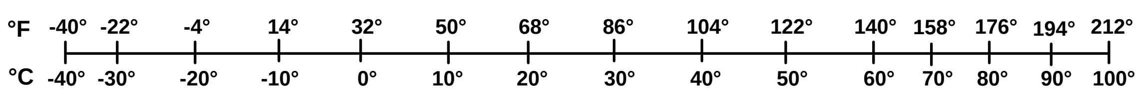
APPENDIX B. Metric/English Conversion Factors

ENGLISH TO METRIC		METRIC TO ENGLISH	
LENGTH (APPROXIMATE)		**LENGTH (APPROXIMATE)**	
1 inch (in)	= 2.5 centimeters (cm)	1 millimeter (mm)	= 0.04 inch (in)
1 foot (ft)	= 30 centimeters (cm)	1 centimeter (cm)	= 0.4 inch (in)
1 yard (yd)	= 0.9 meter (m)	1 meter (m)	= 3.3 feet (ft)
1 mile (mi)	= 1.6 kilometers (km)	1 meter (m)	= 1.1 yards (yd)
		1 kilometer (km)	= 0.6 mile (mi)
AREA (APPROXIMATE)		**AREA (APPROXIMATE)**	
1 square inch (sq in, in^2)	= 6.5 square centimeters (cm^2)	1 square centimeter (cm^2)	= 0.16 square inch (sq in, in^2)
1 square foot (sq ft, ft^2)	= 0.09 square meter (m^2)	1 square meter (m^2)	= 1.2 square yards (sq yd, yd^2)
1 square yard (sq yd, yd^2)	= 0.8 square meter (m^2)	1 square kilometer (km^2)	= 0.4 square mile (sq mi, mi^2)
1 square mile (sq mi, mi^2)	= 2.6 square kilometers (km^2)	10,000 square meters (m^2)	= 1 hectare (ha) = 2.5 acres
1 acre = 0.4 hectare (he)	= 4,000 square meters (m^2)		
MASS - WEIGHT (APPROXIMATE)		**MASS - WEIGHT (APPROXIMATE)**	
1 ounce (oz)	= 28 grams (gm)	1 gram (gm)	= 0.036 ounce (oz)
1 pound (lb)	= 0.45 kilogram (kg)	1 kilogram (kg)	= 2.2 pounds (lb)
1 short ton = 2,000 pounds (lb)	= 0.9 tonne (t)	1 tonne (t)	= 1,000 kilograms (kg)
			= 1.1 short tons
VOLUME (APPROXIMATE)		**VOLUME (APPROXIMATE)**	
1 teaspoon (tsp)	= 5 milliliters (ml)	1 milliliter (ml)	= 0.03 fluid ounce (fl oz)
1 tablespoon (tbsp)	= 15 milliliters (ml)	1 liter (l)	= 2.1 pints (pt)
1 fluid ounce (fl oz)	= 30 milliliters (ml)	1 liter (l)	= 1.06 quarts (qt)
1 cup (c)	= 0.24 liter (l)	1 liter (l)	= 0.26 gallon (gal)
1 pint (pt)	= 0.47 liter (l)		
1 quart (qt)	= 0.96 liter (l)		
1 gallon (gal)	= 3.8 liters (l)		
1 cubic foot (cu ft, ft^3)	= 0.03 cubic meter (m^3)	1 cubic meter (m^3)	= 36 cubic feet (cu ft, ft^3)
1 cubic yard (cu yd, yd^3)	= 0.76 cubic meter (m^3)	1 cubic meter (m^3)	= 1.3 cubic yards (cu yd, yd^3)
TEMPERATURE (EXACT)		**TEMPERATURE (EXACT)**	
[(x-32)(5/9)] °F	= y °C	[(9/5) y + 32] °C	= x °F

QUICK INCH - CENTIMETER LENGTH CONVERSION



QUICK FAHRENHEIT - CELSIUS TEMPERATURE CONVERSION



For more exact and or other conversion factors, see NIST Miscellaneous Publication 286, Units of Weights and Measures. Price $2.50 SD Catalog No. C13 10286

APPENDIX C.
TMC Weather Information Integration Plans

- Kansas City Scout
- Louisiana Statewide and Regional TMCs
- Colorado Springs
- Wyoming Statewide

Kansas City Scout

WEATHER INTEGRATION PLAN

Cover Photo: KC Scout ATMS CCTV image

FINAL
March 9, 2010
Prepared by
Nancy Powell
Project Team Leader

Acknowledgments

KC Scout wishes to thank the valued members of the Weather Integration Team and their organizations for allowing them the time and resources to participate in this project. The names of the team members, their organizations, position titles and email addresses are as follows:

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Illustration Credit: KC Scout

Special Acknowledgments

This project would not have succeeded without the guidance and project oversight provided by Christopher Cluett, Ph.D. and Fred Kitchener, consultants to Federal Highway Administration. We also acknowledge the leadership of Roemer Alfelor, who is with the FHWA Road Weather Management Program (RWMP) and is providing oversight for this national weather integration planning effort. We thank you and hope this effort contributes to the success of other TMCs.

Glossary of Acronyms

AADT	Annual Average Daily Traffic
ATIS	Advanced Traveler Information System
ATMS	Advanced Transportation Management System
AVL	Automatic Vehicle Location
CAP	Common Alerting Protocol
CCTV	Closed Circuit Television
CMS	Changeable Message Signs
D4	District 4 (one of 10 MoDOT Districts)
DMS	Dynamic Message Signs
DOT	Department of Transportation
ER	Emergency Response (MoDOT)
ESS	Environmental Sensor Stations
FHWA	Federal Highway Administration
HAR	Highway Advisory Radio
HQ	Headquarters
ITS	Intelligent Transportation Systems
KDOT	Kansas Department of Transportation
KHP	Kansas Highway Patrol
KTA	Kansas Turnpike Authority
MA	Motorist Assist (MoDOT)
MARC	Mid America Regional Council
MAV	Motorist Assist Vehicle
MCS	Motor Carrier Services
MDC	Mobile Data Computer
MODOT	Missouri Department of Transportation
MOU	Memorandum of Understanding
MPO	Metropolitan Planning Organization
MS	Microsoft
NCDC	National Climatic Data Center
NGD	Next Generation Desktop
NDFD	National Digital Forecast Database
NDOR	Nebraska Department of Roads
NOAA	National Oceanographic Atmospheric Administration
NWS	National Weather Service
OGL	Operation Green Light
RFP	Request for Proposals
RTMC	Regional Transportation Management Center
RWIS	Road Weather Information System
RWMP	Road Weather Management Program
TMC	Traffic Management Center
TMS	Traffic Management System
USDOT	US Department of Transportation
VDS	Vehicle Detection Stations
WFO	Weather Forecasting Office

List of Figures

Revision History

Revision	Issue Date	Status	Author	Comments
001	November 3, 2009	Draft	NP/KC Scout	Under Review
002	February 26, 2010	Draft	NP/KC Scout	Review Completed
003	March 9, 2010	Final	NP/KC Scout	Ready for Distribution

Illustration Credit: KC Scout

Table of Contents

1.0 INTRODUCTION

1.1 Project Description

Severe weather significantly impacts the performance and safety of transportation systems nationwide. The US Department of Transportation began an effort in 2003 to document existing TMC practices relative to weather information and technology integration. In 2007, the USDOT developed an electronic Microsoft Access™ Self-Assessment and Planning Guide (the Guide) to help TMCs assess their current levels of weather integration, identify ongoing needs and assist in creating a practical plan to successfully meet those needs. This project was funded through the FHWA Road Weather Management Program (RWMP) and is directed by Roemer Alfelor. Several sites were selected as test-bed TMCs to participate in the validation and improvement of the initial electronic Guide. These included CalTrans District 3 Regional Transportation Management Center (RTMC) in Sacramento, CA; and, Wisconsin DOT in Milwaukee, WI. Subsequently, additional TMCs have been working with the Guide, including Louisiana DOT, Colorado Springs TMC, Cheyenne, WY and Redding, CA.

1.2 Electronic Self-Evaluation and Planning Guide

This computer-based tool was designed to enable TMCs to conduct their own in-house, weather integration self-assessment evaluation. Six active components exist within the Evaluation portion of the Guide. Based on the TMC's responses to current and desired levels of integration, the Guide returns a series of suggested strategies to help derive a working integration planning document. Those evaluation components include the following tasks:

Figure 1.2 Evaluation Components

IDENTIFY	Relevant weather events in the TMC's jurisdiction
DETERMINE	Type and magnitude of impacts these events have on TMC operations
IDENTIFY	Current strategies for managing the impacts of weather
PRIORITIZE	Needs for weather information and integration
IDENTIFY	Integration strategies & solutions best suited to meet needs
PREPARE	Plan to implement those strategies & solutions

Illustration Credit: KC Scout

1.3 FHWA Project Status 2008 – 2009

In October of 2008, FHWA contracted the services of Battelle to support the RWMP program. Battelle was tasked with selecting three additional TMCs to assess the post-prototype Electronic Guide, by conducting self-evaluations, developing an Integration Plan and communicating potential enhancements to the Guide.

Invitations to participate in the post-development phase were sent to various TMCs around the country who met the following participation requirements:

- Experience with the response to weather conditions that impose moderate to severe impacts to the local, regional and statewide transportation network.
- Responsibility for managing traffic on freeway, arterials, or both.
- A low to medium current level of availability and use of weather information in operations.
- An identified need for improved use of weather information to support TMC decision-making processes.
- A strong interest in participating in the self-assessment process and supporting implementation of the target project activities.

In February of 2009, Kansas City Scout responded and expressed interest in being one of the three TMCs selected to participate in the second phase of the project. On February 17, 2009 a conference call was conducted with Battelle consultant Fred Kitchener of McFarland Management. LLC. The FHWA's project design and objectives were discussed along with background information on KC Scout and its partners in traffic management within the greater metropolitan Kansas City area, including Operation Green Light (OGL), the region's arterial signal management entity and Mid-America Regional Council (MARC), the Metropolitan Planning Organization for the Metro KC area.

1.4 KC Scout TMC Profile

Kansas City Scout (KC Scout) is a comprehensive traffic congestion management and traveler information system conceived, designed, and operated jointly by two Departments of Transportation, a fact that is unique throughout the country. In September of 2001, the Missouri Department of Transportation (MoDOT) and the Kansas Department of Transportation (KDOT) jointly announced their bi-state initiative to address the traffic impacts on over 100 miles of contiguous freeways intersecting both sides of the state line throughout the greater metropolitan Kansas City area.

KC Scout's goal is to offer area drivers the latest in technology and communications to help make their daily commute safer, faster and more manageable. Construction was already underway for MoDOT's new District 4 Headquarters in Lee's Summit, MO and it was decided that a state-of-the-art Traffic Management Center (TMC) could be housed within the new building. The Federal Highway Administration funded 90% of the initial $35.5 million start up costs, with the remaining funding for the project shared between both state Departments of Transportation.

Completed in late 2003, KC Scout has become recognized as an innovative leader in ITS deployment with an integrated system of 138 closed-circuit television cameras (CCTVs), 38 dynamic message signs (DMS), 277 vehicle detector stations (VDS), a highway advisory radio (HAR) system and a dynamic web site offering users the capability of designing their own customized alert messaging profiles.

1.5 Kansas City Scout's Interest in Weather Integration

Prior to selection for the FHWA project, KC Scout was investigating the potential of integrating weather information utilizing the assistance of representatives from the nearby NOAA/WFO in Pleasant Hill, MO along with Emergency Preparedness directors from the city of Independence and Jackson County government. A meeting was held at KC Scout on April 9th, 2009 to assess available NOAA resources that could be integrated into Scout's next-generation ATMS (Advanced Transportation Management System) software, scheduled for deployment in September of 2009. Examples of the types of information discussed included:

- 60-second .shp and .rdg files from NOAA
- Common Alerting Protocol (CAP) tags
- Pigeon™ freeware to facilitate chat sessions.
- Utilization of NOAA's polygon driven advance weather notifications by mile marker designation
- Access to the Jackson County Emergency Action Log
- Prototype DMS weather messages

All of these were items of discussion only, between interested parties, in anticipation of a dedicated effort to develop an integration plan.

1.6 Selection of KC Scout as Participant in FHWA Weather Integration Project

On April 13, 2009, Scout received notification of its selection as a participant in the program. A kick-off meeting with Battelle's consultants was scheduled for May 27, 2009. An initial team of subject matter experts attended the first session and became active partners in the project. The meeting created a team with an initial understanding of the Guide's design, objectives and outputs.

1.7 Timeline of Project Team Activity

Integration team members on Scout's staff met on June 26, 2009 and completed the initial self-evaluation utilizing the electronic Guide. This effort was delayed in part due to various on-going initiatives and activities within the TMC, including work on a Certification Plan for Operators, finalizing requirements for Scout's next-generation ATMS software deployment, and various personnel matters, combined with managing a very active flood season that had tremendous impacts on traffic and maintenance operations alike.

The second team meeting was August 12, 2009. Prior to that session, Scout's initial needs assessment yielded too many options to effectively include in the target implementation plan. Further, team members felt they had under-estimated several of their current integration levels. Consultants recommended a secondary Guide walk-thru with a revised set of objectives and scope.

This task was completed in approximately 25 minutes compared to the original four hours spent on the first assessment earlier in June. After the revised assessment, the team determined they had actually over-stated their current level of integration and formulated a revised and more realistic set of strategic recommendations to meet a set of six high-need, target objectives.

Since the August 12th meeting, Scout has implemented its new ATMS software, finalized its Certification Plan, and developed this Integration Plan document.

2.0 KC SCOUT TMC OVERVIEW

The Kansas City Scout TMC began limited operations in January 2004 with 75 miles of coverage on portions of I-70, I-435, I-35 and several state highways in both Missouri and Kansas. The official public launch was held during a ceremony on September 27, 2004 attended by city, state and federal officials along with media and emergency service providers.

Images Courtesy of KC Scout Partners

2.1 Background Information

KC Scout is unique in being the nation's only bi-state TMC representing a joint partnership between MoDOT and KDOT. It was designed to support safer highways, improve traffic flow and enhance emergency response to incidents. ITS Traffic Management Centers nationwide represent sound investment of transportation spending within the communities they serve.

The national average for one lane mile of pavement construction is $1.5 million. KC Scout's deployment cost was $533,000 per lane mile. New additions cost around $280,000 per lane mile.

2.2 A Look Inside The KC Scout TMC

Figure 2.2.1 Lee's Summit MO - Front entry to KC Scout and MoDOT D4 HQ

Photo Credit: Chris Cluett, Battelle

Figure 2.2.2 Inside KC Scout TMC - View of video wall within the TMC

Photo Credit: Chris Cluett, Battelle

Figure 2.2.3 – TransSuite™ ATMS User Interface as of September 1, 2009

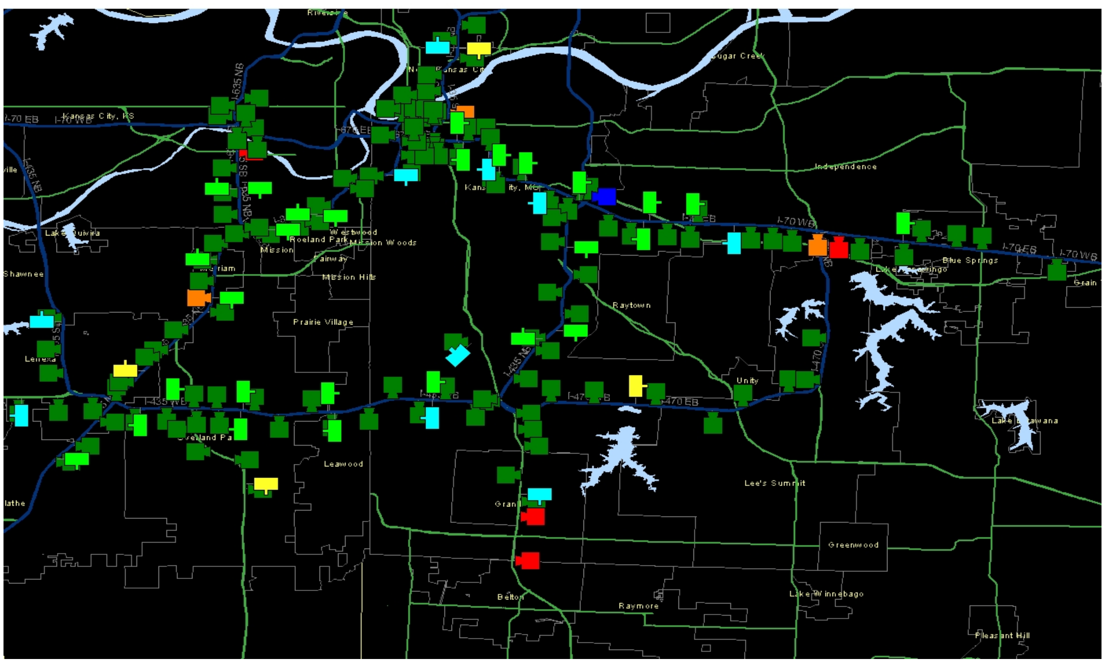


Photo Credit: KC Scout ATMS Screenshot

Legend

CCTV | Disabled CCTV | Blocked CCTV | DMS without message

DMS with Travel Time message | DMS with 2-phase message | Disabled DMS

2.3 Geographical Representation of Scout Coverage Area

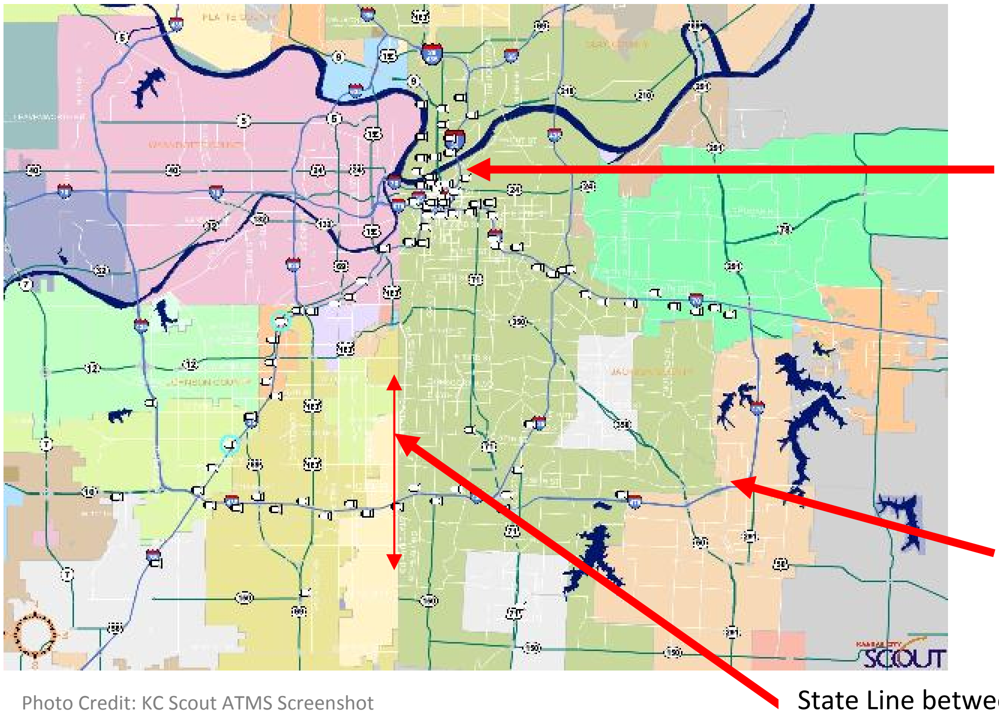


Photo Credit: KC Scout ATMS Screenshot

2.4 Jurisdictional Coverage

Kansas City Scout encompasses the jurisdictional boundaries of Cass, Clay and Jackson counties in Missouri and Johnson and Wyandotte counties in Kansas. Population for those respective counties is as follows:

County	State	Population
Cass	MO	95,781
Clay	MO	206,957
Jackson	MO	664,078
Johnson	KS	516,731
Wyandotte	KS	155,509

Source: http:\\metrodataline.org/xls/population/Population_Estimates_as_of_July_1.xls

2.5 Average Annual Daily Traffic (AADT)

Figure 2.5 shows AADTs for the freeway facilities on the Scout system. The number of incidents on each facility generally correlates with the AADTs for that facility.

Figure 2.5 AADT Data as of September 2009

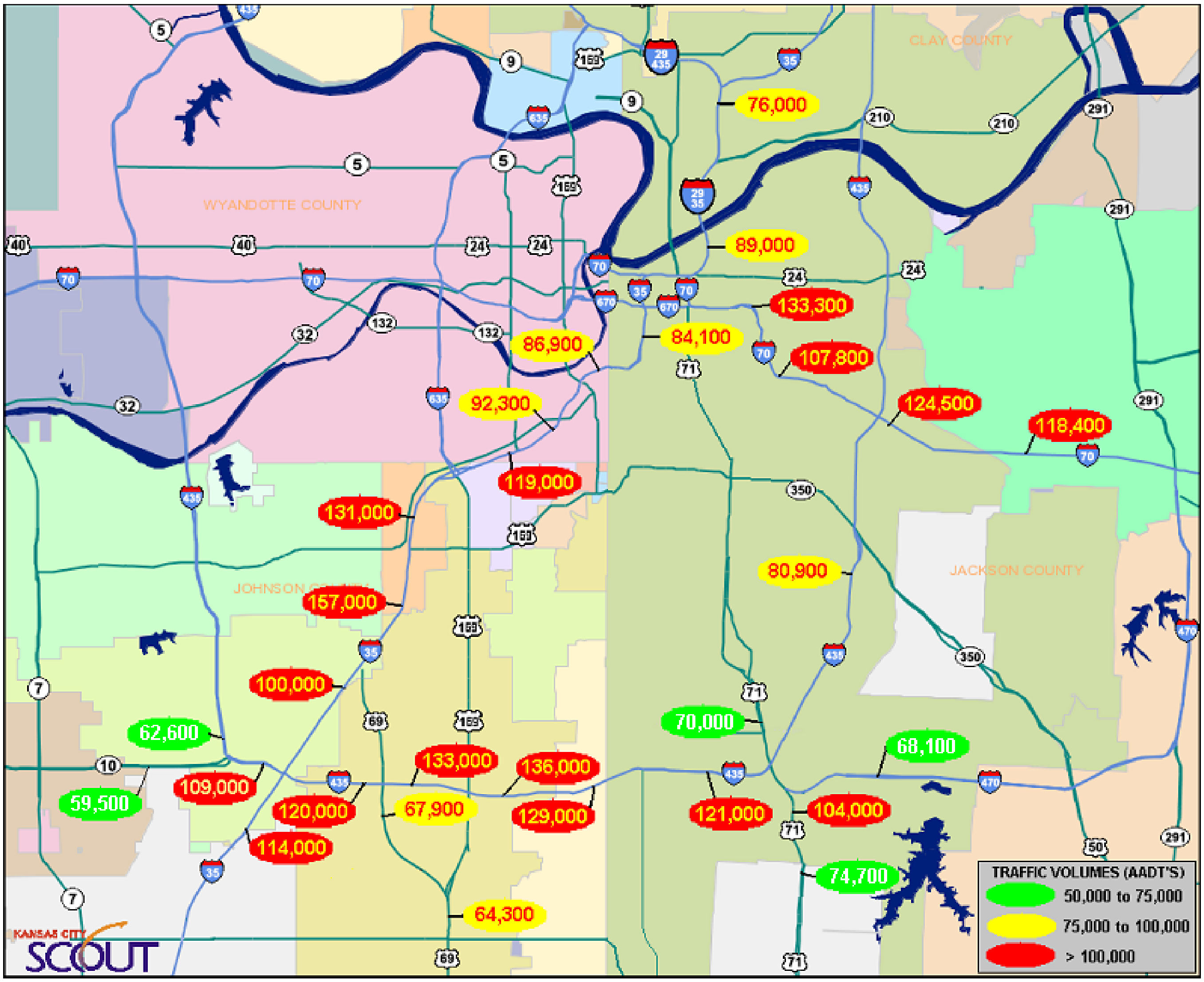


Photo Credit: KC Scout September 2009 Monthly Report, published on the web at www.kcscout.net

Note: The I-70 interstate reaches across Missouri from the Illinois state line to the Kansas state line. It is the nation's fifth largest east-west corridor, passing through 10 states from Maryland to Utah.
Source: http://www.modot.org/interstate/

2.6 Current Levels of KC Scout Staffing

KC Scout has maintained 24/7 operational hours since July of 2005. Staffing levels vary between three shifts (6A-2P; 2P-10P and 10P-6A). Peak hours are staffed with a minimum of two operators and one floor supervisor. Due to the collocation of MoDOT's Customer Service department within the TMC, information relayed via the public is also readily available to Scout operations.

Additionally, KC Scout is supported on both sides of the state line by Motorist Assist operations. They provide on-the-road assistance to motorists needing help with flat tires, low fuel, etc. and actively patrol the interstates looking for road hazards, tagging abandoned vehicles, and assisting with traffic control on incidents where lane restrictions have occurred due to stalls, accidents, traffic stops or weather impacts, such as flooding, ice covered bridges and overpasses, and debris from storm related events.

2.7 Historical Weather Events for the Coverage Area

Accessing the National Climatic Data Center (NCDC), an application within NOAA's website, enables access to archived 50-year storm event data, by state and county. This information is limited in accuracy due to the non-mechanized collection of data prior to the mid-1990s, but it is indicative of the weather events experienced throughout our region within the historical context of a 50 year sample.

Source: http://www4.ncdc.noaa.gov/cgi-win/wwcgi.dll?wwEvent~Storms

2.8 Weather Information Integration Sources

Current sources of weather information readily available to all KC Scout operators include:

- 138 CCTVs on Scout's network
- Internet access to NOAA, the Weather Channel™ and other 3rd party sites
- Local weather/news broadcasts on desktop monitors
- Police & fire radio scanners
- Emergency weather radio
- Missouri state DOT radio communications
- Email from State Emergency Operations Coordinators in both Missouri and Kansas

2.9 Existing Public Weather and Traffic Information Systems

There are numerous sources of publicly available weather and traffic management information and decision-support systems in our region accessible via the Internet. The following is a list of organizations and media outlets that provide website weather and traffic information for the Kansas City area:

- KDOT
- MoDOT
- KC Scout
- NWS and the Weather Channel
- ABC
- CBS
- NBC
- FOX

Each of the four national television network affiliates use Scout's branded CCTV images to provide real-time information about current roadway conditions during their local drive-time news broadcasts. These links are provided via direct fiber optic connectivity to our CCTV network. Camera control rests solely within the TMC.

2.10 Area Traveler Information Websites

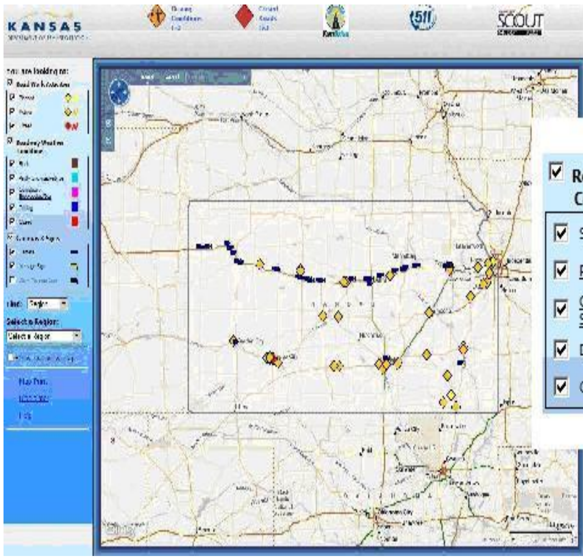
KDOT and MoDOT maintain websites that feature weather components. KC Scout's website posts a current forecast widget along with a link to the Weather Channel.

KANSAS
DEPARTMENT OF TRANSPORTATION
Responsible & Responsive

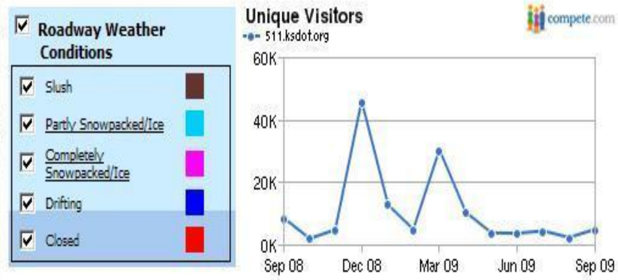
http://www.ksdot.org/

http://www.modot.mo.gov/

Figure 2.10.1 KDOT Website



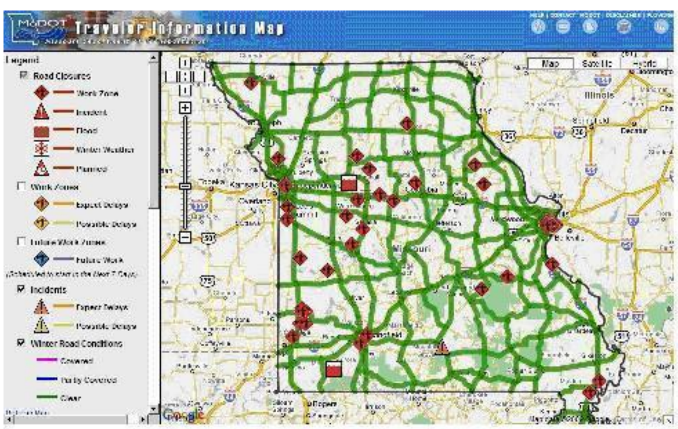
KDOT has maintained their statewide 511 System since 2004. Their current ATIS/511 Program Mgr, Barb Blue, is a member of Scout's Weather Integration Plan team.



Source:http://www.statsaholic.com/511.ksdot.org

Souce: http://511.ksdot.org/KanRoadPublic_VE/Default.aspx

Figure 2.10.2. MoDOT Website

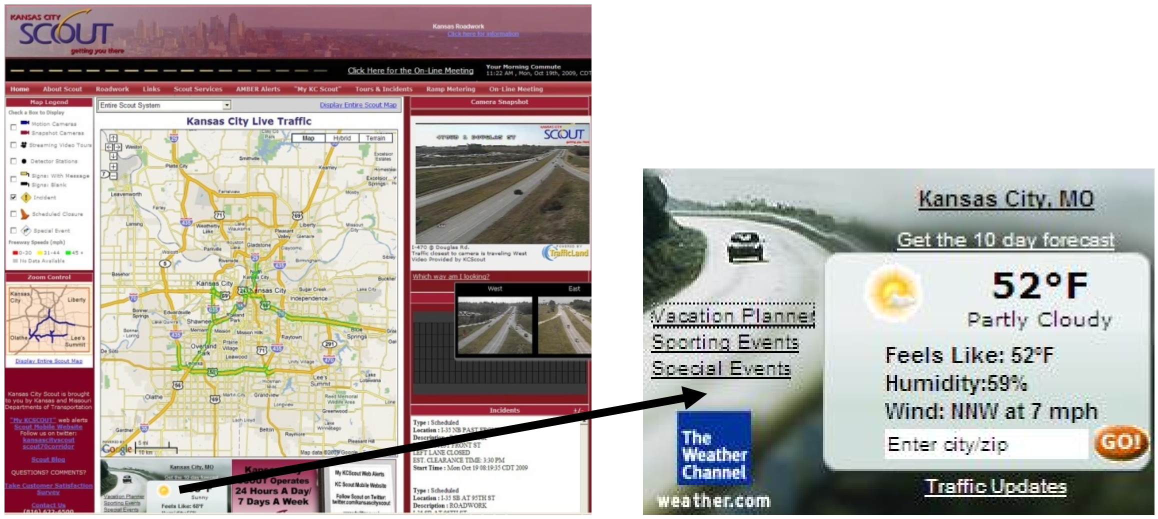


MoDOT has not yet implemented 511 on a statewide basis, but depends heavily on its highly touted 24/7 live operator Customer Service Department. Any caller dialing 1-888-AskMODOT will be greeted by a friendly and knowledgable MoDOT representative with access to vast databases of information concerning the organization's operations within the state. An initiative to deploy 511 throughout Missouri is presently being reviewed by the State's legislature.

Effective 10/27/09, the MARC Board of Directors approved a MOU (Memorandum of Understanding) to administer the design, implementation and operation of a Metro KC area 511 system with funding and technical support from KDOT and MoDOT. An RFP will be forthcoming once funding issues are finalized.

Source: http://maps.modot.mo.gov/travelerinformation/travelerinformation.aspx

Figure 2.10.3 Kansas City Scout Website – Source: www.kcscout.net



Currently, there are no mandated procedures for Scout operators to follow when severe weather occurs in the area. However, operators are extremely self-motivated and encouraged to use whatever tools are available to actively assess weather conditions and their forecasted impacts on our monitored roadways.

2.11 Impacts of Weather Events on KC Scout's Operations

KC Scout's coverage area is at the very crossroads of the nation's network of interstate highways with 105 miles of monitored, contiguous roadways carrying high volumes of commercial, commuter and non-local motorists. Therefore, any weather conditions that affect the highways become of critical importance in terms of congestion, accident response, emissions, and driver impatience.

During winter storm events, MoDOT's traffic department staffs a separate workstation within the TMC, solely for the purpose of monitoring road conditions and reporting on the snowplow activity within its local coverage area. This is of extreme assistance to KC Scout operations because the information can be used to post DMS messages in advance of the plows, helping to keep those lanes clear of through traffic that would otherwise impede plowing activity.

2.12 Internal TMC Weather and Transportation Management Systems

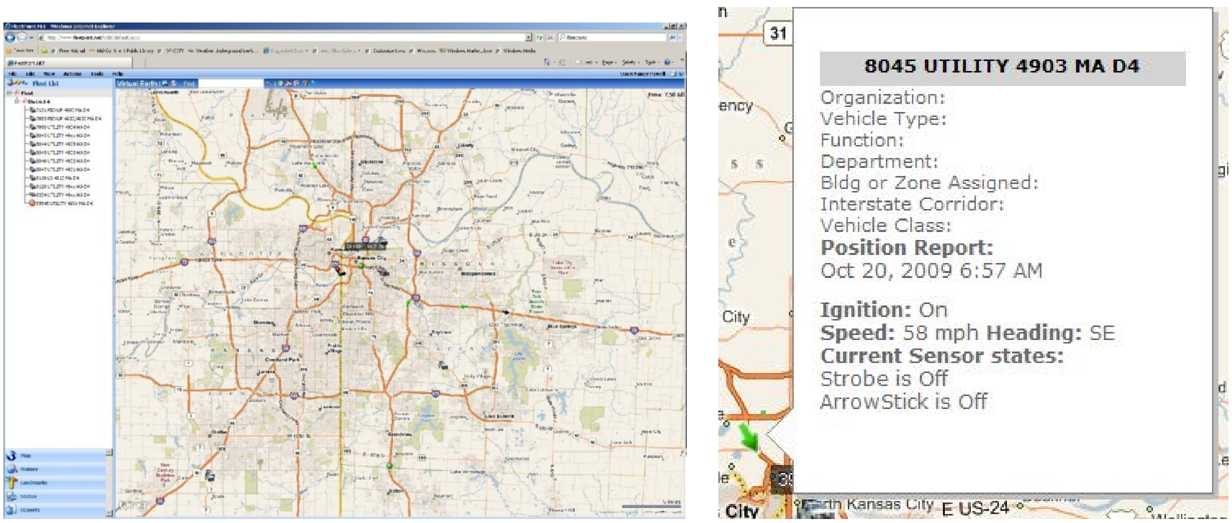
In addition to information obtained via Internet and 3rd party sources, KC Scout relies heavily on its extensive network of CCTVs and first-hand reports of roadway conditions reported by Motorist Assist operators patrolling their respective zones. MoDOT maintenance crews also report road conditions via radio communications which are actively monitored within the TMC.

2.13 MoDOT Motorist Assist

During the AM and PM peak traffic periods, KC Scout operators dispatch five (5) Motorist Assist (MA) operators, supported by a supervisor and Incident Management Coordinator, throughout the Missouri portion of Scout's coverage area. These operators patrol designated routes to assist motorists and report back to the TMC any traffic conditions that warrant close monitoring. Between 8 PM and 5 AM, two (2) Emergency Response (ER) operators patrol the Missouri portion and respond on incidents, primarily to provide traffic control for law enforcement activity on the Scout monitored roadways.

Currently, MA & ER responder vehicles are equipped with AVL (Automatic Vehicle Location) technology enabling TMC operators to monitor vehicle location, speed and direction of travel and sensor status of strobe and arrow board lights. Fleetpoint™ software on the desktop gives TMC Operators a quick, visual reference of all units, whether moving or stopped.

Figure 2.13.1 Fleetpoint™ Mapping Software



Source: KC Scout Fleetpoint™ desktop screenshot http://www.fleetpoint.net/WEB/default.aspx

At present, these MA/ER vehicles are not yet equipped with RWIS (Road Weather Information System) technology, but that is an option currently being tested by Gateway Guide™, the ITS system operated by MoDOT in the greater St. Louis area. A single MDC (Mobile Data Computer) device is being installed on one of the Motorist Assist Supervisor vehicles which patrols between 5AM and 8PM Monday-Friday. Based on the results of these pilot studies, KC Scout Motorist Assist will likely be deploying road condition gathering sensors on its entire fleet in 2010. This collected data will then be made available to MoDOT maintenance crew chiefs for the purpose of coordinating treatment activity as conditions warrant. This data will be provided via MoDOT's intranet web application which permits access from home PCs as well as at district headquarters.

2.14 MoDOT Maintenance Crews

During the winter months, maintenance and field crews regularly report road conditions every 2-4 hours depending upon whether an "event" is in progress, which are then posted on both MoDOT and Scout websites. Because MoDOT's Customer Service department is collocated within the TMC, KC Scout benefits from these early reports which are often the basis for initiating weather condition notifications. MoDOT subscribes to "WeatherOrNot" for its forecast information statewide. During winter storm events, regularly scheduled "Situation Awareness" conference calls are held 2-3 times daily (8:00 am / 2:00 pm / 5:00 pm). All districts are represented and report on current road conditions, air and surface temperatures, sand/salt reserves, numbers of vehicles in service and posted weather message plans. In addition to MoDOT Maintenance personnel, these calls also involve representatives from Motor Carrier Services, Public Affairs, Information Services, National Weather Service and State Emergency Management Agency representatives.

2.15 KHP Motorist Assist Vehicles (MAV)

Roadside assistance is provided in Kansas by the Kansas Highway Patrol. Currently, KHP maintains four vehicles with 8 designated operators who cover 123 miles during day and evening hours. KC Scout operators monitor KHP radio communications and report incidents verified on camera to KHP's Salina, KS dispatch center. Reports on road conditions from enforcement and field crews are closely monitored by TMC operations staff.

2.16 RWIS (Road Weather Information System) Deployment

Remote RWIS sensors measure air temperature, humidity, visibility, wind speed and direction, pavement temperature and surface conditions. Such data is used for winter maintenance and travel information. Units are generally deployed onto fixed infrastructure like poles, bridge overpasses, etc. Additionally, mobile units can be deployed along with AVL on maintenance and responder vehicles to return real-time road condition data to a centralized data receiving station to facilitate immediate maintenance and operational response.

2.16.1 RWIS in KANSAS

KDOT, at present, has no RWIS stations deployed in the greater metropolitan Kansas City area. The closest are just outside the boundaries of Scout's coverage. Currently, select KDOT maintenance vehicles are equipped with air and pavement temperature sensors. However, the environmental data collected is stored on board and is not sending to any receiving site in real time or near real time. A project is underway to equip maintenance vehicles with communication capabilities to transmit the data in real time. This project will be implemented in two phases. Phase 1 of this project will install communications on three maintenance trucks in a district. The data collected by the vehicles will be transmitted in real time to a receiving site where the data is integrated with RWIS data. The benefits of the system will be evaluated. Phase 2 of this project will expand the system.

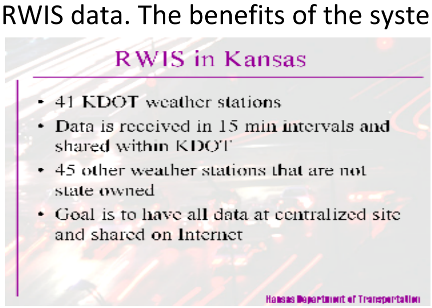


Figure 2.16.1 Source: http://www.ksdot.org:9080/burTransPlan/burovr/its/PDF/Dist4ITSAwarP.ppt#338,15,RWIS

2.16.2 RWIS in MISSOURI

MoDOT D4 which encompasses the KC Scout coverage area, has had RWIS deployed for many years, but the equipment is out-of-date and has not been maintained. These legacy units were scheduled for replacement within FY 2010, however that plan has been put on hold for budgetary reasons. New RWIS devices are being added to the KC Scout network within planned expansion projects as part of new construction. This is addressed more fully in Sections 7 and 8 of this document.

2.17 Other Scout Integration Efforts – Ramp Metering Began November 20, 2009

The effort to implement Ramp Metering in the metropolitan KC area has been under evaluation for nearly ten years. A year-long effort to gain the public's acceptance of ramp metering was tested in mid-November, 2009, when ramp metering began on a stretch of I-435 between Kansas and Missouri as a pilot project. This high profile implementation represents a huge level of effort on the part of Scout's management team members who participated in public meetings, work place lunch-and-learn sessions for businesses located along the affected corridor and answered volumes of emails from the public in response to a well executed media campaign.

To date, the project has been well received. Data is being analyzed to determine the impacts on traffic throughput during the morning and evening peak periods, the only hours the meters are in operation. Scout intends to present a session on the success of Ramp Metering at this year's ITS Heartland Conference in Omaha, NE March 29-31st, 2010.

2.18 Other MoDOT Weather Integration Efforts – Solar Bridge Warming System Initiative

In January 2010, MoDOT became one of the first agencies in the country to consider using solar energy to combat buildup of snow and ice on bridge decks. Pave Guard Technologies, Inc. of Lee's Summit, MO was contracted to install a "solar warming system" on two bridges in District 4. The bridges selected in Clay and Ray Counties are scheduled for deck replacements in 2010 as part of MoDOT's "Safe & Sound Bridge Improvement Program" that is repairing or replacing 802 of the state's worst bridges by the end of 2013.

The warming system operates similar to the way in which radiant heating warms home flooring. Tubing is installed in the bridge deck, through which a heated solution is pumped to keep the deck from freezing. The energy to heat the solution is provided by solar panels mounted near the bridge site. Excess energy produced by the panels when the heating system is not in use can be sold back to local utilities. Bids were let for this construction activity in February 2010, with construction scheduled between April and August of 2010 with target operability by November 2010. MoDOT will evaluate the performance of the systems before making a decision on whether to extend deployment to other bridges.

2.19 Other KDOT Weather Integration Efforts – Wind-Induced Truck Crash Study

In 2009, KDOT contracted with the University of Kansas to conduct a study on predicting and mitigating wind-induced truck crashes on I-70 in Kansas. Interstate 70 was selected for this detailed analysis in conjunction with KDOT's plan to deploy DMS boards between Topeka and the Colorado border. The evaluation consisted of a literature review and analysis of wind-related crashes throughout Kansas over the 3 year period from 2005 to 2007 along with independent weather data. Data was analyzed to determine the correlations between the vehicle characteristics, crash occurrences and weather conditions. The goal was to construct a model that could predict the likelihood of such wind-induced truck crashes, thus providing a tool for increasing safety for both truck drivers and the traveling public. Such crashes often result in interstate closures, creating significant delays and economic loss.

The western and central parts of the state are prone to severe crosswind conditions that result in traffic crashes involving commercial freight or high-profile vehicles. Interstate 70 extends from the western border to the eastern border, covering 424 miles and passes through many of the state's largest cities. The I-70 corridor carries an average annual daily traffic (AADT) of 7,990 to 20,300, of which 2,990 to 4,100 are tractor/trailer commercial vehicles.

The findings of the study were consistent with other agency findings with a notable observation: neither wind speed nor wind gust speed was found to be a factor. More statistically significant were the presence of a thunderstorm, the western most mileposts carrying most risk, presence of concrete pavement and the physical profile of the commercial vehicle. In general, the crash data indicated that Kansas cross-country commercial drivers do alter their driving behavior when winds gust above 40 mph.

3.0 CONCEPTS OF OPERATIONS

There are a variety of regional stakeholders that include maintenance and construction operations, emergency response management, commercial vehicle operations, media partners, and 3rd party data providers who benefit from the information they obtain via the TMC. Weather conditions throughout the year are a significant component, especially during spring thunderstorms and seasonal flooding episodes. During a typical winter season, the area experiences frequent snow storms and disabling ice events which close roads, disrupt local electrical service and impede emergency response to incidents.

3.1 Maintenance and Construction Management

These departments manage fleets of maintenance, construction, or special service vehicles (e.g., snow and ice control equipment). These organizations also participate in incident response by deploying maintenance and construction resources to an incident scene, in coordination with other agencies. Winter weather in our area demands a unified and planned response. Preparation and training begins early in the fall for road and equipment maintenance crews. Missouri state radio systems within the TMC are checked and calibrated for optimal performance. Personnel are assigned and pagers are distributed to those who will be monitoring road conditions during winter weather events. The winter weather season officially begins October 15th and runs until April 15th.

3.1.2 MoDOT Performance Measurements

One of the significant weather operational goals to which MoDOT management is held accountable is "Time to meet winter storm event performance objectives on major and minor highways." Data is collected in the winter event database, and analyzed so that improvements can be made. After each winter event, such as a snow or ice storm, area maintenance personnel submit a report indicating how much time it took to clear snow from the major and minor highways. Data collection for this measure runs from November through March of each winter season. After a storm ends, the objectives are to restore the major highways to a clear condition as soon as possible and have the lower-volume minor highways open to two-way traffic and treated with salt and/or abrasives at all critical areas such as intersections, hills and curves as soon as possible. The end of the storm is defined as when freezing precipitation stops accumulating on the roadways, either from falling or drifting conditions. This data is updated in January and April Management reports.

In 2008, there were two winter events in November and nine in December. The Kansas City district received, on average, between seven and ten inches of snow. The average time to meet the performance objectives on the major highways varied from 2.9 to 3.7 hours over the reporting period. The average time to meet the performance objectives on the minor highways varied from 3.8 to 5.3 hours. Current strategies to improve these numbers include pursuing equipment enhancements, testing new materials and continued reliance on verifiable advance weather notification.

3.2 Emergency Management Agencies

KC Scout interfaces with 57 local area law enforcement and fire department agencies. Operators monitor scanners within the TMC as well as receive calls directly from public safety agencies via a dedicated law enforcement hotline. Relationships with law enforcement personnel have improved dramatically due to the proactive efforts of Scout's Incident Management Coordinator, who spent 30 years as a traffic control specialist with the Lenexa KS Police Department. Through joint efforts, we now have a signed cooperative accord with these agencies to work together to improve the safety and efficiency of our shared urban transportation systems and support the continued economic growth in the region.

3.3 Commercial Vehicle Operations

The configuration of eleven major transportation routes monitored by KC Scout is highly utilized by commercial carriers. When road conditions or incidents cause any of the interstate routes to be closed in one direction for greater than two hours, it is Scout's policy to notify Motor Carrier Services (MCS). They in turn, notify their network of commercial carrier contacts to limit the disruption caused either by detour routes or the carriers own decision to wait out the closure. In the case of weather related closures, this can quickly become a problem for urban arterial roads not equipped to handle the commercial traffic, compounded by local jurisdiction efforts to keep those roads open and clear. Advance planning for weather events is therefore of critical importance to traffic managers, commercial carriers, emergency responders and the general public.

3.4 Media Partners and 3rd Party Providers

KC Scout interfaces with a number of media partners who relay information received from Scout to their own subscribers. As social networking sites have gained in widespread popularity, KC Scout has incorporated them into their outbound information stream. Such sites as Twitter™ and Facebook™ now carry KC Scout incident messages to an even wider audience. In situations of severe weather, these sites become highly useful to motorists seeking the latest information on road conditions.

Scout's own website (www.kcscout.net) incorporates a 3rd party application entitled "MyKCScout" allowing subscribers to create a customized alert notification for their specific route(s) of choice, by day-of-week, time-of-day and type of notification (email or instant text message). Users can opt to include weather alerts, homeland security alerts, Ozone and Amber alerts. In this way, KC Scout enables use of "push" technology to disseminate immediate information regarding conditions that affect the traveling public.

3.5 TMC Desktop Applications

Each operator position is equipped with four (4) monitors; one 19", two 17" and one 15". Operators have the flexibility to configure their workstations to their own preferences, but desktop real estate is extremely limited due to the number of active windows required for day-to-day monitoring and incident management. It is customary for a user to constantly toggle between 10-12+ open windows, among the four available monitors, throughout a typical work shift. By integrating weather information into our existing processes, it will provide smoother flow between applications, more timely response to changing conditions and improved proactive decision-making based on readily available, real-time data.

4.0 RELATIONSHIP TO OTHER PLAN DOCUMENTS

MoDOT and KDOT planning organizations contribute to the overall KC Scout ITS architecture plan under guidance from the Scout Board of Directors, the TMC Manager and Scout Project Manager.

http://www.modot.mo.gov/

http://www.ksdot.org/

4.1 Mid America Regional Council (MARC)

Mid America Regional Council (MARC) is a nonprofit association of city and county governments and the area MPO (Metropolitan Planning Organization) for the bi-state Kansas City region. Governed by a board of local elected officials, MARC serves nine counties and 120 cities and is a strong supporter and contributor to KC Scout, holding a seat on the Board of Directors.

http://www.marc.org/

4.2 Operation Green Light (OGL)

Operation Green Light (OGL) is an initiative within MARC to coordinate arterial traffic signal timing plans across 20 jurisdictional boundaries in Kansas and Missouri. The project built an extensive wireless communication system to 633 signals across the region to allow for signals to be better coordinated and respond to problems in real time. Of the 633 signals in Phase 1, nearly 90 percent are online and almost 80 percent have new timing plans during peak travel periods.

Benefits in specific corridors have resulted in a 21 percent decrease in travel times; an 18 percent reduction in fuel consumption; and a 15 percent decrease in emissions. Operation Green Light's real-time computer systems allow staff to investigate signal problems and change signal timing without field visits. Analysts can also manage many problems in real time rather than waiting for a citizen complaint.

Currently, OGL operates out of MoDOT D4, separate from KC Scout. However, integration is in the initial phase with an OGL workstation operational within the TMC. Efforts to integrate arterial with freeway ATMS are in the planning stages. Both OGL and KC Scout use TransSuite™ ATMS applications which enhances the potential of a successful integration effort.

http://www.marc.org/transportation/ogl/

5.0 WEATHER INTEGRATION SELF-EVALUATION PROCESS

As noted in the chart provided in the Acknowledgments section of this document, the members of the KC Scout Weather Integration project team constitute a diverse cross-section of transportation and weather professionals. Operations and maintenance are represented along with TMC staff and outside agency professionals.

5.1 Initial Strategy for Determining Geographic Scope of the Project

KC Scout's unique bi-state characteristics determined the geographic scope of this project. It was decided by the team that the current physical boundaries of Scout's CCTV/DMS/VDS coverage areas would be a logical integration target. Major expansion efforts are in the planning and construction stages in both states that will extend the scope of the current network. These initiatives involve the placement of CCTVs along the I-70 corridor between Kansas City and St. Louis as an enhancement to the 20 CMS boards (10 each, East and West) that KC Scout now manages as part of its operation. Similarly, KDOT is deploying cameras and DMS boards along their portion of I-70 all the way across the state to the Colorado border. These will eventually be monitored by KC Scout. The year-round weather characteristics are fairly uniform between both states, so there was no need to break out each as a separate zone for assessment purposes.

5.2 Initial and Subsequent Self-Evaluations using the Electronic Guide

It is worth noting that our team conducted an initial and subsequent self-evaluation using the Electronic Guide. Our first effort in June of 2009 took approximately 4 hours to conduct since there was limited consensus among the TMC staff participants as to the type and frequency of weather events experienced in our area and our current levels of integration.

Upon completion of the initial assessment, the Guide yielded a total of thirteen High Need Strategies. Output reports were distributed to team members for review and further discussion. Once reassembled, the internal team concluded that the results underestimated the current level of integration due to the extensive number of high need strategies identified by the Guide. When the full project team met again with the Battelle consultants on August 12, the problem was presented for discussion and it was recommended that we re-run the assessment tool with an eye on reducing the 13 high-need target strategies by 50% to yield a more reasonable integration plan goal. That effort took less than 30 minutes and quite surprisingly, revealed that the initial assessment actually “overstated” Scout’s current level of integration. The target “high needs” were reduced from the original thirteen down to six, which is a far more realistic integration goal.

5.3 Guide Recommended Target Strategies

The Guide’s design encompasses five specific dimensions of integration: Operational, Physical, Technical, Procedural and Institutional. Within these dimensions, there are 11 Items of Integration that make up the Self-Evaluation. The following chart reflects the criteria for each level of integration:

Figure 5.3.1 Matrix of Criteria for 11 Levels of Integration

Levels of Integration	Level 1	Level 2	Level 3	Level 4	Level 5
Use of Internal Weather Information Resources	Camera Imagery	Radar, Satellite, General forecasts	Level 2 + RWIS data	Level 3 + AVL/MDC and radio	Level 4+ Analysis of field data (frost, snow, ice…)
Use of External Weather Information Resources	Media provided forecasts	Internet provided forecasts	Field Observer or probe provided scheduled info from entire route system	Contractor provided surface info targeted to operations needs of the TMC	Direct connection between private info providers & TMC software
Availability of Weather Information	Weather Cable Channel subscription	Video displayed, Internet provided radar or satellite images	Field Observers providing scheduled road/conditions reports	Level 3+ Vendor provided daily surface weather info	Meteorologist located within TMC providing forecasts and interpretation
Frequency of Weather Forecasts	Receive weather forecasts on a request basis	Receive weather forecasts once daily	Receive periodic forecasts several times a day	Receive hourly updates several times a day	Receive continuous updates in real-time

Levels of Integration	Level 1	Level 2	Level 3	Level 4	Level 5
Frequency of Weather/Road Weather Observations	Receive weather forecasts on a request basis	Receive weather observations once hourly	Level 2+ observations when thresholds are exceeded	Receive observations every 10 min. if exceeding thresholds	Receive observations continuously with data if thresholds exceeded
Weather Information Coordination	Intra-TMC committee tasked with weather information coordination	Identified TMC or maintenance staff person tasked with weather info coordination at TMC	Dedicated weather operations supervisor	Meteorology staff within the TMC forecasting and interpreting weather info	Co-location of the EOC/OEM
Extent of Coverage	Sparse set of isolated locations	Network of scattered locations	Corridor-Level	Multiple corridor/Sub-regional	Regional/Statewide
Interaction with Meteorologists	Focus group or informal gatherings of local exoerts from transportation mgmt & weather	Develop checklist of routine weather awareness activities	Periodic staff meeting that includes a meteorologist to discuss weather info needs	With a meteorologist present, conduct post-event debriefing & assessments	Daily personal briefings and integrated interruptions by meteorology staff within the TMC
Alert Notification	Monitor media outlet, Internet page, or data stream for critical events	Telephone call list	Manual email/paging system	TMC road weather system(RWIS) generated specific notifications via email/pager	Automatic notification through center-to-center communications
Decision Support	Ad-hoc implementation of weather mgmt strategies	Use of Quick-reference flip cards at workstations	Response scenarios to determine projected outcomes of weather conditions	Automated condition recognition and advisory or control strategies operator use	Level 4 without operator initiated intervention
Weather/Road Weather Data Acquisition	Media reports	Internet/satellite data sources	Across agency intranet and dedicated phone	Dedicated comm. Link to state, federal & private	Level 4+ vehicle derived weather data

The output results of the KC Scout self-assessment evaluation are discussed in detail in Section 7 of this document. Reports from all five sections of the Guide are included in the Appendices.

5.4 Six Scout Identified High Needs Target Strategies

The six High Needs target strategies that became the focus of this Integration Plan document are as follows:

Disseminate weather information to a larger set of stakeholders and users in the region (including transit and other modes)

Provide better enroute information on weather conditions to aid travelers in their decision-making

Develop and implement clear, written policies and procedures for handling weather events

Improve the timeliness of weather management response including deployment of field personnel and equipment

Provide assistance in interpreting weather information and how best to adjust operations in light of that information

Create better real-time information on road conditions during weather events

The above strategies are discussed specifically in Section 6 of this document. Our ability to proactively utilize real-time weather information to enhance advisory notification to the travelling public, field maintenance and operations staff as well as our media partners, will extend Scout's value far beyond its current level of reactive response.

6.0 INTEGRATION NEEDS

By design, the Self Evaluation Electronic Guide incorporates a base of eleven items of integration that represent best practices from various TMCs that participated in the initial FWHA/Battelle pilot study.

6.1 Eleven Items of Integration

- Use of Internal Weather Information Resources
- Use of External Weather Information Sources
- Availability of Weather Information
- Frequency of Weather Forecasts
- Frequency of Weather/Road Weather Observations
- Weather Information Coordination
- Extent of Coverage
- Interaction with Meteorologists
- Alert Notifications
- Decision support
- Weather/Road Weather Data Acquisition

Each of these 11 Items of Integration was then categorized into five levels of integration, ranging from minimal to maximum integration as shown in Figure 5.3.1 in the previous section.

6.2 Five Categories of Integration Needs

Section 4 of the Electronic Self-Assessment Guide elicited responses that identified TMC Operational Needs, ranging from low to medium to high, which then fell within five specific categories, as follows:

- Advisory functions (relating to a TMC providing travel advisories during a weather event)
- Institutional coordination (relating to coordinating within and outside a TMC)
- Control functions (relating to the control functions of a TMC during a weather event)
- Treatment functions (relating to road treatment functions for a TMC during a weather event)
- Weather information gathering (relating to obtaining better weather data and information)

6.3 Scout's Identified "High Level Needs"

Scout's results from the self-assessment exercise produced the following six "High" level needs and their respective categories. Note: Control Functions did not produce an output need since the focus of KC Scout's TMC is to provide information, not necessarily exercise control functions other than those associated with information response, notification and monitoring activity.

Figure 6.3 KC Scout's High Level Needs

Need Area	Need Statement	Level
Advisory Operations	Disseminate weather information to a larger set of stakeholders and users in the region (including transit and other modes)	High
Advisory Operations	Provide better enroute information on weather conditions to aid travelers in their decision-making	High
Institutional Coordination	Develop and implement clear, written policies and procedures for handling weather events	High
Treatment Operations	Improve the timeliness of weather management response including deployment of field personnel and equipment	High
Weather Information Processing and Gathering	Assistance in interpreting weather information and how best to adjust operations in light of that information	High
Weather Information Processing and Gathering	Better real-time information on road conditions during weather events	High

6.4 Advisory Operations Needs

Weather information is currently gathered from available sources, but it is not integrated into TMC operator desktop applications. This therefore requires that an operator "open" an Internet Explorer window to gain access to the Internet. Each separate window requires valuable desktop real estate on the current 4-monitor screen configuration at the workstation. This becomes a juggling act to keep the information readily accessible while not interfering with ATMS functionality.

In order to meet the need "to disseminate weather information to a larger set of stakeholders…" it is first necessary to improve the means of obtaining this information and integrating it into those applications which drive our notification processes.

Similarly, in order to meet the need "to provide better enroute information on weather conditions…" Scout must first receive weather forecast information that is highly reliable, verifiable and time-based so as to be of use to motorists currently on the roadways or those planning imminent travel through the area.

6.5 Institutional Coordination

The need to develop and implement clear, written policies and procedures for handling weather events is of extreme importance to our 24/7 operation. KC Scout operators come from a wide variety of backgrounds and transportation experience levels. Not all of them have the same "Employer of Record" given the mix of MoDOT, KDOT, KHP and contractor staffed positions. In order to maintain a high degree of consistency within TMC operations, it is essential that policies and procedures be communicated clearly and frequently.

Training is an ongoing TMC function. Toward that goal, KC Scout has developed a comprehensive Operator Certification program that assures a continuum of training. This Weather Integration Plan will become a component of that certification program upon its completion.

As a bi-state managed TMC, Scout maintains a unique organizational structure with oversight by both DOTs. This requires a high degree of coordination and cooperation between all parties. Weather is a common entity, but how we manage it may differ by organizations. Thus, having a Weather Integration Plan developed by representatives from the various stakeholders should prove invaluable to our TMC.

6.6 Treatment Operations

Maintenance Operations and the TMC are entirely separate entities. Day-to-day maintenance and construction activities are communicated via written RoadZone reports issued by both DOTs, via email, with the next day's planned work zones. These communications are issued from the Community Relations departments and go to both internal and external recipients. In the event of a weather event, these work zones are noted as "weather permitting."

During winter weather season, there is a closer relationship between maintenance operations and the TMC. During an event that requires the use of snow plows, salt trucks and specialized maintenance vehicles, the traffic department at MoDOT staffs a workstation within the TMC to monitor the clearance activity, stay apprised of changing conditions via the CCTVs and weather forecast information available within the TMC and upload road information into the MoDOT Traffic Management System (TMS). This database populates the road condition information available on the MoDOT website Traveler Information Map.

Improved coordination with maintenance efforts may be the biggest opportunity for integration and also the most difficult, given the diverse culture between maintenance operations and the TMC. By sharing weather information and observations with field personnel, the TMC can help them with visual confirmation of the roadway conditions and by integrating weather elements into our notification system, keep them better apprised of changing conditions during an event. Similarly, direct communication from field personnel regarding observed changes in road conditions can be the first indicator of weather situation impacts. Open communication between departments is the desired outcome of any integration effort.

KC Scout now provides Missouri road condition information to motorists via HAR updates utilizing software that interprets written scripts to deliver the most current information. This information is updated no less than four times every 24 hour period or as changing conditions warrant. Once maintenance personnel update the MoDOT website map indicating current road conditions, a Scout operator updates the text-to-voice script and uploads the revisions to the HAR application.

6.7 Weather Information Processing and Gathering

Within our TMC, we have several individuals with prior experience interpreting weather data. One of our full-time operators serves in a part-time capacity as an Administrative Officer for Missouri Disaster Medical Assistance Team. His role is to monitor and report on current weather activity once his unit is activated. His past experience involved on-scene disaster response when the western Kansas town of Greensburg was devastated by an F5 tornado on May 4, 2007. Two other full-time operators had previous careers in Emergency Dispatch, one a 30 year veteran 911 dispatcher and another with 15 years Fire dispatch background. Both TMC supervisors have backgrounds in Fire and 911 dispatch respectively. This heightened level of emergency management expertise serves our department well. However, we could do a better job of educating all TMC staff on weather information interpretation.

By integrating weather information into our ATMS application, we would reduce the margins of error in interpreting data and be better equipped to issue advance warning notifications utilizing our DMS network and outbound communication sources. Maintenance functions could potentially be linked to the weather components of our ATMS to enable better manpower and equipment scheduling during significant weather events.

7.0 INTEGRATION SOLUTIONS

Completion of Section 5 of the Self-Evaluation Guide yielded a set of Target Strategies that identify the delta between where we are now and where we want to be in terms of weather information integration. Those results are shown in the figure below, with shading to represent the identified **current** versus **recommended** level of integration.

Figure 7.0.1 Outcomes of the Electronic Guide Assessment Target Level Criteria

Levels of Integration Current Recommended	Level 1	Level 2	Level 3	Level 4	Level 5
Use of Internal Weather Information Resources	Camera Imagery	Radar, Satellite, General forecasts	Level 2 + RWIS data	Level 3 + AVL/MDC and radio	Level 4+ Analysis of field data (frost, snow, ice…)
Use of External Weather Information Resources	Media provided forecasts	Internet provided forecasts	Field Observer or probe provided scheduled info from entire route system	Contractor provided surface info targeted to operations needs of the TMC	Direct connection between private info providers & TMC software
Availability of Weather Information	Weather Cable Channel subscription	Video displayed, Internet provided radar or satellite images	Field Observers providing scheduled road/conditions reports	Level 3+ Vendor provided daily surface weather info	Meteorologist located within TMC providing forecasts and interpretation
Frequency of Weather Forecasts	Receive weather forecasts on a request basis	Receive weather forecasts once daily	Receive periodic forecasts several times a day	Receive hourly updates several times a day	Receive continuous updates in real-time
Frequency of Weather/Road Weather Observations	Receive weather forecasts on a request basis	Receive weather observations once hourly	Level 2+ observations when thresholds are exceeded	Receive observations every 10 min. if exceeding thresholds	Receive observations continuously with data if thresholds exceeded
Weather Information Coordination *No integration at the present time*	Intra-TMC committee tasked with weather information coordination	Identified TMC or maintenance staff person tasked with coordination weather information at TMC	Dedicated weather operations supervisor	Meteorology staff located within the TMC forecasting and interpreting weather info	Co-location of the EOC/OEM

Levels of Integration Current Recommended	Level 1	Level 2	Level 3	Level 4	Level 5
Extent of Coverage *No integration at the present time*	Sparse set of isolated locations	Network of scattered locations	Corridor-level	Multiple-corridor/sub-regional	Regional/Statewide
Interaction with Meteorologists *No integration at the present time*	Focus group or informal gatherings of local professionals from transportation mgmt and weather communities	Develop checklist of routine weather awareness activities	Periodic staff meeting that includes a meteorologist to discuss weather information needs and responses	With a meteorologist present, conduct post-event debriefing and regular assessments to improve response	Daily personal briefings and integrated interruptions by meteorology staff within the TMC
Alert Notification	Monitor media outlet, Internet page, or data stream for critical events	Telephone call list	Manual email/paging system	TMC road weather system(RWIS) generated specific notifications via email/pager	Automatic notification through center-to-center communications
Decision Support	Ad-hoc implementation of weather mgmt strategies	Use of Quick-reference flip cards at workstations	Response scenarios to determine projected outcomes	Automated condition recognition and advisory or control strategy	Level 4 without operator initiated intervention
Weather/Road Weather Data Acquisition	Media reports	Internet/satellite data sources	Across agency intranet and dedicated phone acquisition	Dedicated comm. Link to state, federal & private data	Level 4+ vehicle derived weather data

Figure 7.0.2 Chosen Levels of Integration following Evaluation results (highlighted in gray)

Levels of Integration	Level 1	Level 2	Level 3	Level 4	Level 5
Use of Internal Weather Information Resources	Camera Imagery	Radar, Satellite, General forecasts	Level 2 + RWIS data	Level 3 + AVL/MDC and radio	Level 4+ Analysis of field data (frost, snow, ice…)
Use of External Weather Information Resources	Media provided forecasts	Internet provided forecasts	Field Observer or probe provided scheduled info from entire route system	Contractor provided surface info targeted to operations needs of the TMC	Direct connection between private info providers & TMC software
Availability of Weather Information	Weather Cable Channel subscription	Video displayed, Internet provided radar or satellite images	Field Observers providing scheduled road/conditions reports	Level 3+ Vendor provided daily surface weather info	Meteorologist located within TMC providing forecasts and interpretation
Frequency of Weather Forecasts	Receive weather forecasts on a request basis	Receive weather forecasts once daily	Receive periodic forecasts several times a day	Receive hourly updates several times a day	Receive continuous updates in real-time
Frequency of Weather/Road Weather Observations	Receive weather forecasts on a request basis	Receive weather observations once hourly	Level 2+ observations when thresholds are exceeded	Receive observations every 10 min. if exceeding thresholds	Receive observations continuously with data if thresholds exceeded
Weather Information Coordination	Intra-TMC committee tasked with weather info coordination	Identified TMC or maintenance staff person tasked with coordination of weather info	Dedicated weather operations supervisor	Meteorology staff located within the TMC	Co-location of the EOC/OEM

Levels of Integration	Level 1	Level 2	Level 3	Level 4	Level 5
Extent of Coverage	Sparse set of isolated locations	Network of scattered locations	Corridor-level	Multiple-corridor/sub-regional	Regional/Statewide
Interaction with Meteorologists	Focus group or informal gatherings of local professionals from transportation mgmt and weather communities	Develop checklist of routine weather awareness activities	Periodic staff meeting that includes a meteorologist to discuss weather information needs and responses	With a meteorologist present, conduct post-event debriefing and regular assessments to improve response	Daily personal briefings and integrated interruptions by meteorology staff within the TMC
Alert Notification	Monitor media outlet, Internet page, or data stream for critical events	Telephone call list	Manual email/paging system	TMC road weather system(RWIS) generated specific notifications via email/pager	Automatic notification through center-to-center communications
Decision Support	Ad-hoc implementation of weather mgmt strategies	Use of Quick-reference flip cards at workstations	Response scenarios to determine projected outcomes of weather conditions	Automated condition recognition and advisory or control strategies operator use	Level 4 without operator initiated intervention
Weather/Road Weather Data Acquisition	Media reports	Internet/satellite data sources	Across agency intranet and dedicated phone acquisition	Dedicated comm. Link to state, federal and private data sources	Level 4+ vehicle derived weather data

Figure 7.0.3 Summarized Levels of Chosen Integration Targets: (shown in gray)

Integration Item	Current Integration Level	Guide Recommended Integration Level	Chosen Weather Integration Level	Rationale/Comments
Use of Internal Weather Information Resources	2	3	3	RWIS to be deployed in Missouri in 2010
Use of External Weather Information Resources	2	4	3 & 4	Utilizing field and contractor provided data
Availability of Weather Information	2	4	3 & 4	Utilizing field and vendor provided daily surface info
Frequency of Weather Forecasts	4	4	4	Hourly updates several times a day is reasonable
Frequency of Weather/Road Weather Observations	3	3	3	Observations hourly or whenever pre-determined thresholds are exceeded
Weather Information Coordination	0	3	1 & 2	Project team will remain active with project coordinator from TMC
Extent of Coverage	0	5	1 & 2 & 3	Coverage up to corridor level
Interaction with Meteorologists	0	3	1 & 2 & 3	Informal meetings, informational checklists and scheduled sessions with Meteorologist from NWS
Alert Notification	1	4	4	RWIS generated data received electronically
Decision Support	1	3	3	Utilization of 'what if' scenarios for training and projected outcomes
Weather/Road Weather Data Acquisition	2	3	3	Intra-agency and dedicated hotline for notification and advisories

7.1 Use of Internal Weather Information Resources

At the current integration level, KC Scout is positioned within Levels 1 and 2 which include our network of 138 CCTVs and available radar and satellite information obtained via the Internet to identify active and forecasted weather conditions. To reach our target of Level 3 integration, we will be adding new RWIS functionality by deploying six (6) new RWIS devices within the current Scout construction schedule for three planned expansion projects along I-29/I-35, I-435 and US 71 Hwy. These projects are in various stages of construction and all will be completed by 2011.

MoDOT has a number of installed but depreciating RWIS devices which will ultimately be replaced at some point in the future. These units have not been maintained over time and discussions with Maintenance have determined where legacy unit replacements should be installed to provide maximum monitoring of road conditions at sites where numerous accidents are known to occur, principally near bridges, overpasses and high water areas. In addition, Scout has recommended locations that also provide CCTV monitoring functionality.

By opting to include RWIS within new construction projects, KC Scout takes advantage of the new power and cabinet installations and simply adds the necessary RWIS hardware as a component. This results in shifting the cost from an already tightly restricted operating budget to funds already pre-approved for construction activity. Use of this additional data element will involve operator and support services training. This will become part of the Operator Certification Training Program with coordination and train-the-trainer sessions furnished by the selected vendor. Procedures will need to be developed to report and troubleshoot any malfunctions within the RWIS data link. As an added internal feature of KC Scout, a public relations campaign may be developed to promote awareness of the RWIS upgrade and the additional road condition information that it will provide to the public. Scout has its own Community Relations Specialist assigned to developing and managing these types of public relations campaigns which include press releases, website announcements and public meetings as required.

7.2 Use of External Weather Information Resources

Scout's current use of internet and broadcast media-provided weather information will be improved to Levels 3 and 4 (and possibly 5) by incorporating data interconnection links between the TMC and NOAA's Pleasant Hill Weather Forecasting office. Efforts are currently underway to integrate the data elements necessary to populate Scout's ATMS mapping application with polygonal link layer(s) that would automatically display as a layer on the ATMS map application when weather conditions reached pre-determined thresholds across the TMC coverage area. This would trigger planned notification messaging via the DMS and outbound web links as well as internal notifications to DOT maintenance and construction personnel. Alert notifications are discussed further in Section 7.9.

Training, support and procedural policies will need to be developed, tested and published. Activity resulting from this enhanced level of integration would need to be tracked, measured and analyzed to gauge its effectiveness in reducing traffic impacts associated with severe weather events.

7.3 Availability of Weather Information

Ad-hoc operator usage and video wall display of internet (radar and satellite) image information will be replaced with inbound and integrated road/driving condition reports received via RWIS, mobile data computer (MDC) and field reporting personnel. The same factors of training, support and policy development will be expected to accompany this level of integration. A higher degree of interdepartmental communication between the TMC and Maintenance will be necessary to achieve full benefit of this solution, in terms of advisory and treatment management decisions.

7.4 Frequency of Weather Forecasts

No marked level of change is required here, particularly since implementation of the above strategies will integrate forecast data into TMC standard operations, making it a "push" rather than "pull" data element.

7.5 Frequency of Weather/Road Weather Observations

Frequency is less a concern, since the information will be inbound on an ongoing basis. Reports on these new data elements will need to be developed so that results can be measured and tracked.

7.6 Weather Information Coordination

By virtue of this Weather Integration Project, our TMC has already convened an "Intra-TMC committee" to promote weather information coordination across all partner channels. It is Scout's expectation that this committee will continue to meet on a bi-annual (or seasonal basis) to revisit the Plan, make new recommendations based on developing technologies and involve new stakeholders as roles and responsibilities change.

As champion of this initial integration effort, TMC Supervisory personnel will function as committee chairperson(s) and facilitators for ongoing integration activity.

7.7 Extent of Coverage

This solution is an outgrowth of the RWIS and AVL deployment strategies already discussed. Scout initially identified specific locations that would warrant installation of updated RWIS data collection technology such as high-water collection points, bridges and overpasses, and segments of the monitored roadway that habitually are the site of incidents during inclement weather. However, it was decided to forego those locations in favor of installing RWIS as part of the construction efforts for three (3) pre-approved KC Scout Expansion projects. This enabled funding for RWIS to be included within current construction budgets taking into consideration planned power and cabinet installation. Only the RWIS devices themselves and the software required to operate them will need to be purchased. It is estimated that the initial cost to deploy six (6) new RWIS remote side-fire devices along three expanded corridors will be approximately $55,000 with maintenance provided by the vendor at a cost of $3-4K each per year. Maintenance and response vehicles equipped with AVL/MDC sensor technology will provide "roaming" sources of road condition data.

In terms of corridor level coverage, Scout's TMC will still be dependent upon notification by field personnel when road conditions deteriorate due to weather, particularly when those locations are outside the CCTV scope of coverage. For the entirety of the Missouri I-70 E/W corridor, KC Scout currently has responsibility for activating DMS message boards when capacity is reduced due to incidents and/or roadwork. This area of responsibility is being enhanced by the addition of CCTV cameras near the twenty DMS boards along I-70. Initially, KC Scout will have view-only capability with camera control retained by maintenance management.

This is a part of a Missouri statewide effort to deploy Omnicast™ technology for CCTV coverage of critical intersections on major and minor highways. Scout supervisory personnel have already participated in training sessions for the new software, which is being installed and tested throughout the state. It is expected that this additional ITS deployment will be fully functional and available for operator training after July 1, 2010.

Further, KDOT has designated Scout as a backup TMC for activation of their DMS during severe weather events along the I-70 corridor from the Missouri state line to the Colorado border. This effectively expands Scout's extent of coverage to span Interstate 70 from Illinois to Colorado.

7.8 Interaction with Meteorologists

Scout is fortunate to have a regional NOAA/Weather Forecasting Office, located less than 10 miles from the TMC. Two of this Plan's team members are NOAA meteorologists: Julie Adolphson, Meteorologist In Charge, and Andy Bailey, Warning Coordination Meteorologist. We share a mission to utilize technology to save lives. To date these individuals have participated in this integration project in an advisory capacity. They have furnished the necessary technical information for our software vendor to build-in the geo-coding necessary to integrate NWS data elements into Scout's ATMS. We are in the process of identifying the pre-determined weather event "thresholds" that would warrant notification passing from NOAA in the form of data "tags" directly into the ATMS layer to prompt an operator to activate a "weather incident" following the same procedures now used for traffic events. As recently as October 22, 2009, an article appeared in the Hutchinson KS newspaper lauding the number of lives saved in the May 4, 2007 Greensburg, Kansas F5 tornado, due to science and technological advances that provided early warning notification. Eleven deaths were attributed to the 1.7 mile wide tornado which hit the town at 9:55 pm and destroyed virtually every building. Without Doppler radar and experts assessing the path of the storm and issuing warnings, it is estimated that the death toll could have easily reached into the hundreds. For a link to the article, go to http://www.hutchnews.com/Print/weatherman.

7.9 Alert Notification

This integration solution will be achieved by progression from passive weather monitoring within the TMC to automatic alert notification via TMC standard operating procedures, just as we now treat incidents of any nature that impact the capacity of the roadways.

Currently, KC Scout provides electronic alerts to subscribers of "MyKCScout" via the Scout website. Subscribers create password protected "Custom Trip" profiles for specific day of week, time of day and route criteria. MyKCScout alerts are then generated automatically and sent as email and/or text messages when incidents meeting user-specified criteria are initiated. Weather alerts are selectable options and the data is automatically sent from the National Weather Service (NWS) when issued. This involves no interaction on the part of TMC operators to create or cancel such alerts.

Figure 7.9.1 Customized Alert Entry Screen

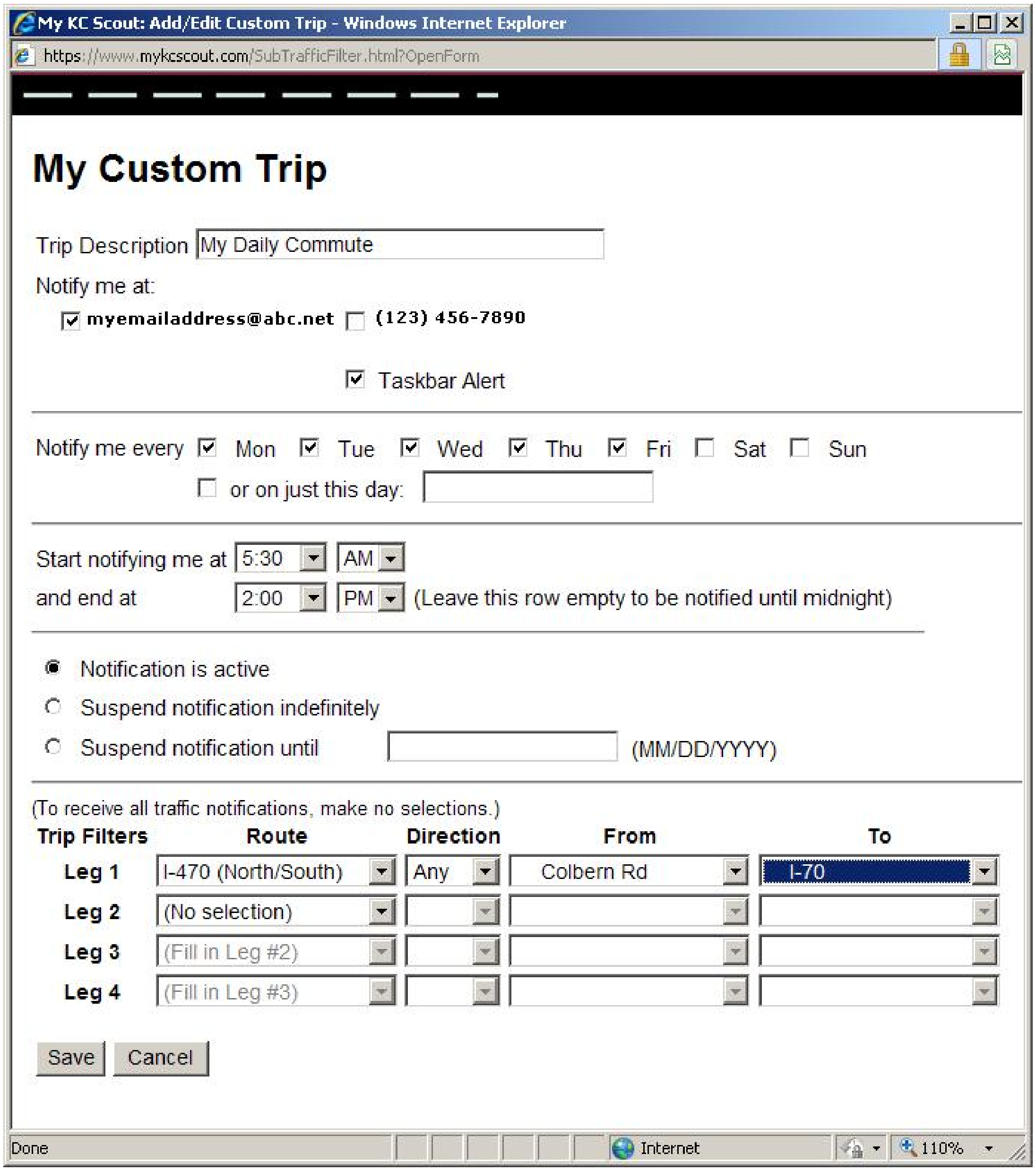


Photo credit: Screenshot of myKCScout Custom Alert Profile, available to subscribers through KC Scout's website: http://www.kcscout.net

Figure 7.9.2 Activation of Weather Alert Filter

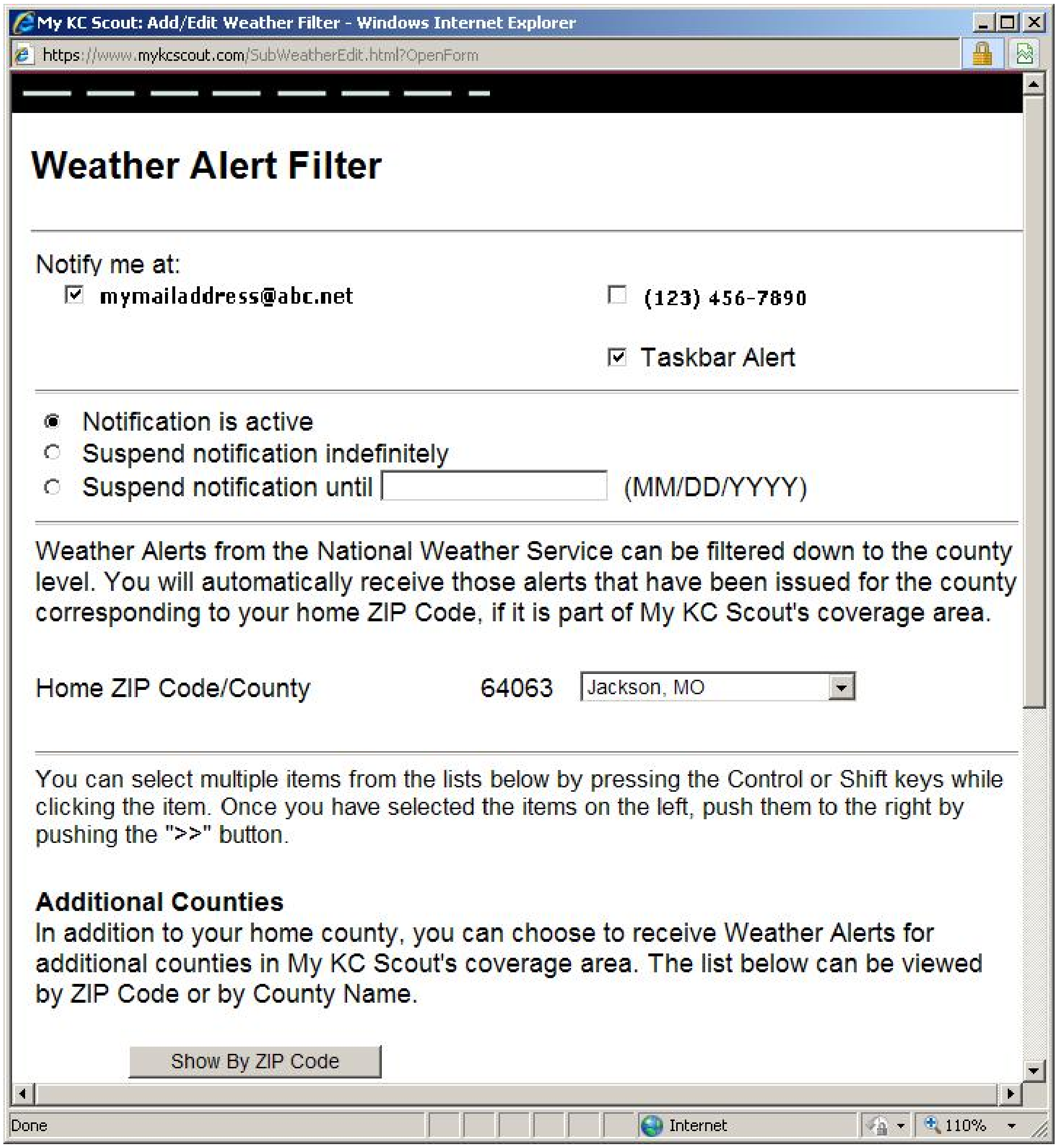


Photo credit: Screenshot of myKCScout Custom Alert Profile, available to subscribers through KC Scout's website: http://www.kcscout.net

Expanding the audience for TMC issued weather alerts will require the identification of key personnel along with their preferred notification method (email, text, phone, etc.). Scout currently maintains a similar type of notification methodology for any incidents involving lane restrictions along the I-29, I-35 and I-70 corridors. Operators complete an information datasheet upon notification of an event/incident on the corridor and then this information is posted on the respective DMS board(s), added into the Traveler Information Map (if the duration is anticipated to exceed 2 hours) and an email is sent to a group list of over 100 MoDOT personnel. Any updates or changes are similarly communicated and a clearance email is also sent.

7.10 Decision Support

Scout will develop response scenarios with recommended advisory messages upon receipt of developing weather condition information. The predetermined “thresholds” are in the process of being defined and policy and procedure guidelines will need to be written. This represents a significant new effort for the Scout Management team. It is our firm policy to have any and all operational changes approved by Scout’s Board of Directors. Institutional changes represent the greatest challenge and will require the most time to implement.

7.11 Weather/Road Weather Data Acquisition

As discussed in early sections, RWIS and AVL/MDC technologies are currently being planned or considered for deployment in Scout’s coverage areas. On the MoDOT side, replacement RWIS installation and maintenance costs will be incurred by Maintenance, with Scout paying only for the monthly recurring data delivery costs. Current estimates indicate an initial capital investment of approximately $70,000 for 8 planned stations with $4,000 per year for five years for maintenance once funding becomes available.

Currently, KDOT maintenance vehicles are equipped with air and pavement temperature sensors. However, the environmental data collected is stored on board and is not being sent to any receiving site in real time or near real time. KDOT has a current project (ITS-14) to equip maintenance vehicles with communication capabilities to transmit the data in real time. This 2-phase project will involve the integration of this data with RWIS data to provide improved road weather information and environmental conditions monitoring. Since no RWIS stations are deployed within Scout’s Kansas coverage areas, any data received regarding road conditions will be an added TMC information resource.

In 2009 KDOT received an FHWA ITS Grant for the Integration of an Overland Park (KS) Flood Warning System to be installed at both City Hall and the Overland Park Fire Training Center. Fiber connectivity is already underway for the project and Scout has been involved in the project status meetings. It is anticipated that Scout will receive notification via automated phone messaging or email from Overland Park personnel when an imminent flooding condition is detected. KC Scout will then contact KHP dispatch and KDOT personnel to handle traffic diversion and DMS boards will be activated and incidents created within Scout’s ATMS. The target date for the initial implementation phase of the project is mid-2010.

8.0 IMPLEMENTATION OF INTEGRATION PLAN

As discussed earlier in Section 6.3, the Self-Evaluation Guide identified six “High Need” target strategies. This implementation plan is intended to address the steps necessary to achieve these high need objectives.

The six target strategies include:

- Disseminate weather information to a larger set of stakeholders and users in the region (including transit and other modes)
- Provide better enroute information on weather conditions to aid travelers in their decision-making
- Develop and implement clear, written policies and procedures for handling weather events
- Improve the timeliness of weather management response including deployment of field personnel and equipment
- Provide assistance in interpreting weather information and how best to adjust operations in light of that information
- Create better real-time information on road conditions during weather events.

It is beneficial to note that many of the selected strategies involve tasks that are both moderate in terms of their complexity and cost to implement. These involve readily available data link connections from external sources and internally developed policies and procedures. In cases where equipment must be purchased, installed and maintained (i.e., RWIS or AVL/MDC) the costs are justified because the added level of service they will enable Scout to provide is believed to warrant their expenditure.

8.1 Scout's TransSuite™ ATMS Software

Providing the core platform for Scout's TMC operation is its state-of-the-art ATMS (Advanced Traffic Management System). Within this framework, CCTVs, DMS and VDS are controlled and monitored.

Prior to September 2009, Scout used a UNIX based system that furnished little support for enhancement development, report generation or operator efficiency. Many manual workarounds were developed by Scout staff which were time consuming to create and maintain, but did provide the level of utility desired to create and monitor incidents, track and trend activity and provide meaningful management reporting capabilities. Inbound weather information consisted of daily MoDOT radio broadcasts of WeatherOrNot™ furnished forecasts or Internet-based weather media channels monitored on individual desktops. Scout operators became adept at identifying changing weather conditions while constantly monitoring CCTV cameras spanning 100-plus miles of interstate in the metro KC area. Weather was simply not a component of the ATMS architecture platform.

On September 1, 2009, Scout successfully deployed TransSuite™ ATMS software. This represented the first major update to Scout's core ATMS platform since the TMC began formal operation in January of 2004. The effort resulted from two years of detailed planning, needs assessment and testing, largely driven by what had been lacking in the legacy system, ie, scalability, adaptability and ease-of-use. The Windows/SQL-based TransCore™ product deployment was nearly seamless and has streamlined all the processes associated with creating and monitoring traffic incidents, activating and updating DMS message boards and linking all pertinent incident information into easily accessible databases and reporting tools. The user-interface utilizes a series of "layers" which visually represent infrastructure (CCTVs, DMS, VDS), traffic incidents, scheduled events (roadwork) and special events (heavy traffic stadium/concert events).

With this added flexibility, Scout will soon be able to integrate weather information into the user-interface as another "layer" utilizing the lat/long data link connectivity available from external weather information sources, i.e. NOAA, NWS's National Digital Forecast Database (NDFD), Meridian-511 providers, etc. As an example, when a weather condition exists that meets pre-selected alert threshold criteria, a "layer" will "activate" on the operator's ATMS desktop map application, signaling creation of a weather event type "incident" with applicable DMS messaging and outputs to Scout's website and subscriber-configured WebAlert applications. The immediacy of being able to notify motorists of a quickly developing severe weather condition will aid in their decision-making and hopefully reduce severe weather related crashes on the interstate. The next upgrade is scheduled for April 2010 and will accommodate this added weather data functionality. Training on the use of these new elements will require TMC staff development efforts along with support system documentation, but the resources currently exist to complete these efforts.

8.2 Partnerships between Stakeholders

Partnerships between stakeholders are well established. Scout's Board of Directors has endorsed this project as a planning mechanism, but all proposed changes would first need to be reviewed and approved before any formal implementation can begin. This Board meets every three months but opportunities exist to communicate with them as needed. The next regularly scheduled meeting will be March 25, 2010 at which time the Board will receive this Integration Plan for review and comment.

The following week, KC Scout will be presenting a breakout session on this Weather Integration Project at the ITS Heartland Chapter of ITS America 2010 Conference in Omaha, NE on March 29, 2010. The audience consists of more than 100 ITS professionals from Missouri, Kansas. Iowa, Nebraska and Oklahoma along with FHWA executives and other state officials.

Photo Courtesy of ITS Heartland Chapter of ITS America 2009 Conference held in Topeka, KS.

8.3 Implementation Schedule (Phasing and Sequencing)

Figure 8.3.1 Implementation Timeline

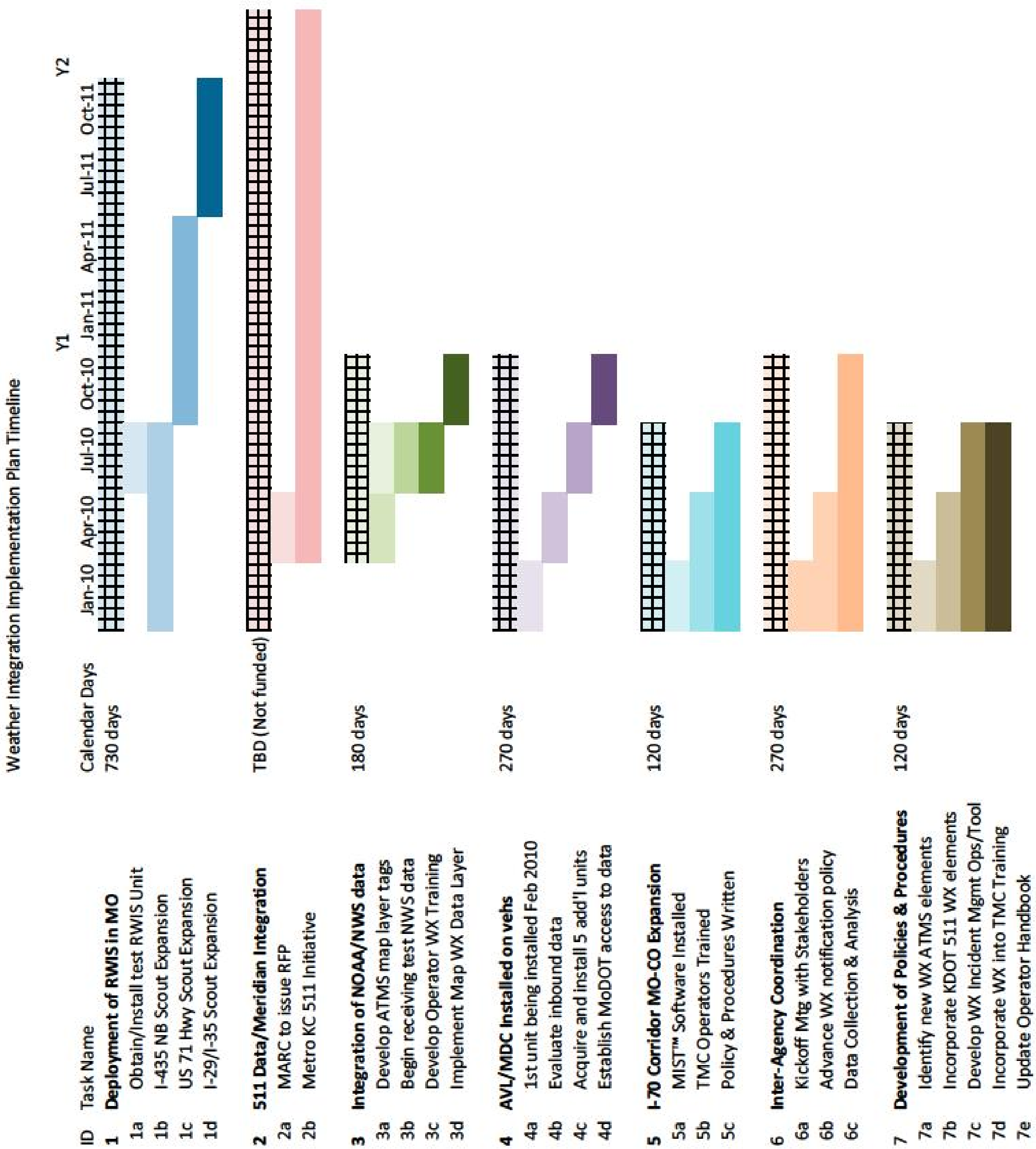


Illustration Credit: KC Scout

Figure 8.3.2 Identified Project Tasks for Implementation

ID	Task Name	Owner	Inputs	Outputs	Timeline
1	RWIS Deployment (MO)	Jason Sims (KC Scout)	Contracts Awarded Scout Expansion -I-435 NB -US 71 Hwy -I-29/I-35	-Realtime WX data -Improved Maint response time -Accident reduction analysis -Cost/Benefit Analysis	January 2010 Start (as part of current construction activity on three (3) Scout expansion projects
2	Meridian Data Integration from 511 (KS/MO)	Barb Blue (KDOT)	Existing KDOT 511 Data -36 sources -24x7 -Road & Segment specific -Available Clarus data	-Link to Scout Website/ATMS -Map Layer integration -Threshhold Targets ID’d	KDOT 511 data available now KC Metro 511 On hold pending funding
3	Integration of NOAA datasets enabling alert notification of impending adverse weather conditions	Don Spencer (KC Scout)	-shp.files -polygon links	-ATMS Map Layer -Scout Specific WX alerts output via Web -Group list notification	Spring 2010
4	AVL/MDC installed on MA/ER vehicles	Jason Sims (KC Scout)	-Road condition data elements -Displayed on TMC Operator workstations	-Real-time WX information -Ability to provide advance info to maint personnel	Single evaluation unit installed to be installed March of 2010 Add’l deployments Summer 2010
5	I-70 Corridor Mgmt (from MO to CO)	Jason Sims (KC Scout)	-KDOT Maint & Ops notification of WX Events	-Activation of KDOT WX messaging and CCTV monitoring	Spring 2010
6	Inter-Agency Coordination	Jason Sims (KC Scout)	KDOT, MODOT, NDOR City of Omaha Topeka TMC	-Proactive WX messaging -TMC POC specific emails	Summer 2010
7	Development of Policies and Procedures Relative to Weather Integration	Nancy Powell (KC Scout)	-Integrated weather layer within ATMS software -Integrated KDOT 511 weather data elements (Clarus)	-Incorporate Weather incident mgmt into Standard Operating Procedures and Training Manuals	Summer 2010

8.3.1 RWIS Deployment

MoDOT has determined that the existing RWIS stations currently installed throughout the metropolitan KC area are in need of replacement due to their age and unreliability. These legacy units will be replaced in accordance with Maintenance schedules and budget approvals. Six (6) new RWIS devices are being installed by KC Scout in conjunction with three (3) pre-approved expansion plans according to the schedule shown in Figure 8.3.3.

Figure 8.3.3 Planned RWIS Installation in Conjunction with Scout Construction Activity

KC Scout Expansion Route	Status	# of RWIS units	Vendor	Target Completion
I-435 NB	Work in progress	2	High Sierra	August 2010
US 71 Hwy	Work in progress	2	High Sierra	Fall 2010
I-29/I-35	Start July 2011	2	High Sierra	Fall 2011

The decision to include RWIS station installation in the construction contracts for KC Scout's expansion efforts enabled the costs to be incurred within the preapproved capital contract budgets and not incurred as expenditures from Scout's operating budget. Given the current recession climate for DOTs in general, this represents a shift from reactive expenditures to proactive planned spending since the power and cabinet installation are already included in each of the above route expansions. It is estimated that the added cost of including the above 6 RWIS within the construction contracts totals $55K with an estimated annual operating cost of $3,800 per unit which includes maintenance provided by the equipment vendor.

The units will deliver surface temperature, dew point, air temperature and pavement friction data. This data will be available to aid Maintenance and Motorist Assist in being proactive regarding treatment and monitoring during weather events, thus reducing patrol activity to obtain physical measurements and saving labor, equipment and recurring costs. Response time for treatment will be more timely and effective. It is KC Scout's intent to incorporate the integration of RWIS XML output data as a layer within the TransSuite™ ATMS as early as August 2010.

Another benefit of having RWIS data will be the ability to analyze and compare accident reduction efforts associated with monitored areas versus segments without RWIS detection. The results will hopefully help to make the case for future RWIS deployments and ultimately save lives and damage to property.

RWIS Deployment in Kansas

KDOT maintains 42 RWIS sites statewide, eight with CCTV capability and a ninth combined unit planned for April or May. However, none of these current and planned sites are located along the KS I-70 corridor. The majority of KDOT sites are located in rural areas of the state and are maintained and repaired by a maintenance employee dedicated to their upkeep. KDOT added CCTVs and DMS along the I-70 corridor in 2008-2009 and these will be monitored by Scout on an as-needed, backup basis to help support KDOT's newly established virtual TMC in Wichita.

Additionally, the KTA (Kansas Turnpike Authority), maintains 53 RWIS sites along their 236 miles of toll road connecting Kansas City, Topeka and Wichita. Negotiations with KTA and KDOT ITS personnel are ongoing in pursuit of cooperative agreements concerning access to CCTVs and data. KTA uses HAR (Highway Advisory Radio) instead of DMS to advise motorists of inclement weather conditions. It also promotes the use of 511 statewide for weather information updates. KC Scout's proactive response to adverse weather conditions in Kansas will enable motorists traveling from Missouri across into Kansas and beyond to the Colorado border with road closure information well in advance to aid travelers in their decision making.

8.3.2 Meridian Data Integration from 511 Systems

KDOT utilizes a Meridian solution to provide 511 Traveler Information which includes Clarus data among 36 varied sources of 24x7 available information elements that are road and segment specific. Efforts have begun to identify those data elements that can be utilized by Scout's ATMS system and its website. The next Scout TransSuite™ ATMS software upgrade scheduled for April 2010 includes tags for incorporating KDOT weather data into the mapping program.

Barb Blue, KDOT's ITS 511 Program Manager and member of Scout's Weather Integration project team has been assigned project management responsibility for a planned Metro KC 511 Initiative to be administered by MARC (Mid-America Regional Council). An RFP was being developed for release in the spring of 2010, but due to a lack of dedicated funding, this project is presently on hold.

8.3.3 Integration of NOAA Datasets

The participation and response of team members from NOAA's NWS Pleasant Hill Reporting Station has been integral to the success of this project from a planning perspective. On November 3, 2009 team members were given a tour of the weather station by Andy Bailey, Warning Coordination Meteorologist. Numerous follow up discussions have taken place since then. KC Scout was honored to host the year-end meeting of the Kansas City Chapter of the American Meteorological Society on December 16, 2009. Over 30 weather professionals toured the Scout TMC, many visiting Scout for the first time. Their understanding of the role of the TMC in providing information to the motoring public was greatly enhanced and further solidified our existing relationship with forecasters from our local media outlets. The TransSuite™ ATMS software upgrade scheduled for April 2010 has been designed to include geo-coded shapefiles (.shp) containing lat/long coordinates and data attributes from the NWS for inclusion as a map layer. Efforts are ongoing to identify how these new weather elements will be communicated via website, MyKCScout Alerts, and group list notification. Scout includes Alerts from the NWS in its MyKCScout Customized Alerts application, but due to the length and frequency of messages received from the NWS during an event, most subscribers quickly opted out of this text-messaging option.

It is envisioned that predefined adverse weather thresholds can be identified and linked to specific weather messages. Once reached, the geographical reference would be displayed as a layer on the ATMS mapping application and trigger the creation of a weather event and its associated messaging content and extent. In this way, weather will be treated as an “incident” just like any other traffic-affecting activity within the Scout system, and along the I-70 corridor from St. Louis to Colorado.

MoDOT currently subscribes statewide to weather service data for state internal use only, provided by WeatherorNot™ out of Shawnee, KS. However, KC Scout is not permitted to pass their forecast information through to our Website at the present time. Integration with the NWS will provide timely and targeted information that motorists can use and access readily whether on the road or planning their travel.

8.3.4 AVL/MDC Equipment Installation on Motorist Assist/Emergency Response Vehicles

KC Scout utilizes Interfleet™ to monitor the location and operating status of our Motorist Assist/Emergency Response fleet vehicles. This enables us to dispatch units more effectively and monitor their safety while on response calls. As a pilot project, KC Scout is deploying one (1) MDC (Mobile Data Computer) unit purchased at a cost of $2,500 with a $40 monthly recurring communications charge. This unit is scheduled for installation during March 2010 on one of the Motorist Assist Supervisor vehicles, which is in the field patrolling from 6 am until 8 pm. The unit will gather road condition data similar to RWIS and display these elements on the current Interfleet™ software interface at all TMC operator consoles. Based on an evaluation of the accuracy and integrity of the data received, Scout intends to purchase additional units for 2 vehicles per shift and 1 Emergency Response vehicle for overnight and weekend patrols. Funding for these units will become available after July 1, 2010 and is included in Scout’s Fiscal Year 2010-2011 budget. Purchase decisions will be made accordingly once funding is approved.

8.3.5 I-70 Corridor Management (St. Louis to Colorado Border)

8.3.5.1 MODOT I-70 Corridor Activity

KC Scout began messaging along the I-70 corridor between Kansas City and St. Louis beginning in 2007. In the event of an incident, MoDOT maintenance personnel or MSHP (MO State Highway Patrol) contacts Scout with all pertinent lane closure information and TMC operators activate appropriate DMS boards for the incident utilizing software from LedStar™. In addition, an email is generated to a group list of I-70 vested parties advising them of the incident. This email is updated whenever the conditions change or the incident clears. In 2009, six (6) DMS boards along the I-29 and I-35 corridors, north of the metro KC area were added to this process.

In late 2009, MoDOT began deploying CCTVs in close proximity to the 20 existing corridor DMS (10 in each direction). Access to the cameras will initially be view-only by TMC operators utilizing OmniCast™ technology. District employees will manage CCTV activity for their respective areas. Having CCTV view capability will assist TMC staff in assuring that incident information stays current and that no boards remain active after the clearance of an event. The ability to view actual road conditions along the corridor in conjunction with integrated weather data will assist Scout in monitoring changing weather patterns and responding proactively with appropriate messaging and advisory communications.

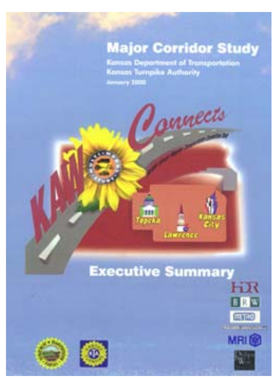
8.3.5.2 KDOT I-70 Corridor Activity

In January 2010, KC Scout staff completed training on KDOT's Telvent MIST™ ATMS application in order to provide KDOT with after-hours activation of weather messaging on DMS boards along the KS I-70 corridor. Current operating system resource constraints exist between the Scout TransSuite™ ATMS and MIST™ application when running simultaneously on a workstation. Therefore, an Operator must log off of Scout's ATMS while activating a KDOT message board. To help alleviate this incompatibility between software applications, Scout purchased a laptop dedicated to the KDOT application only.

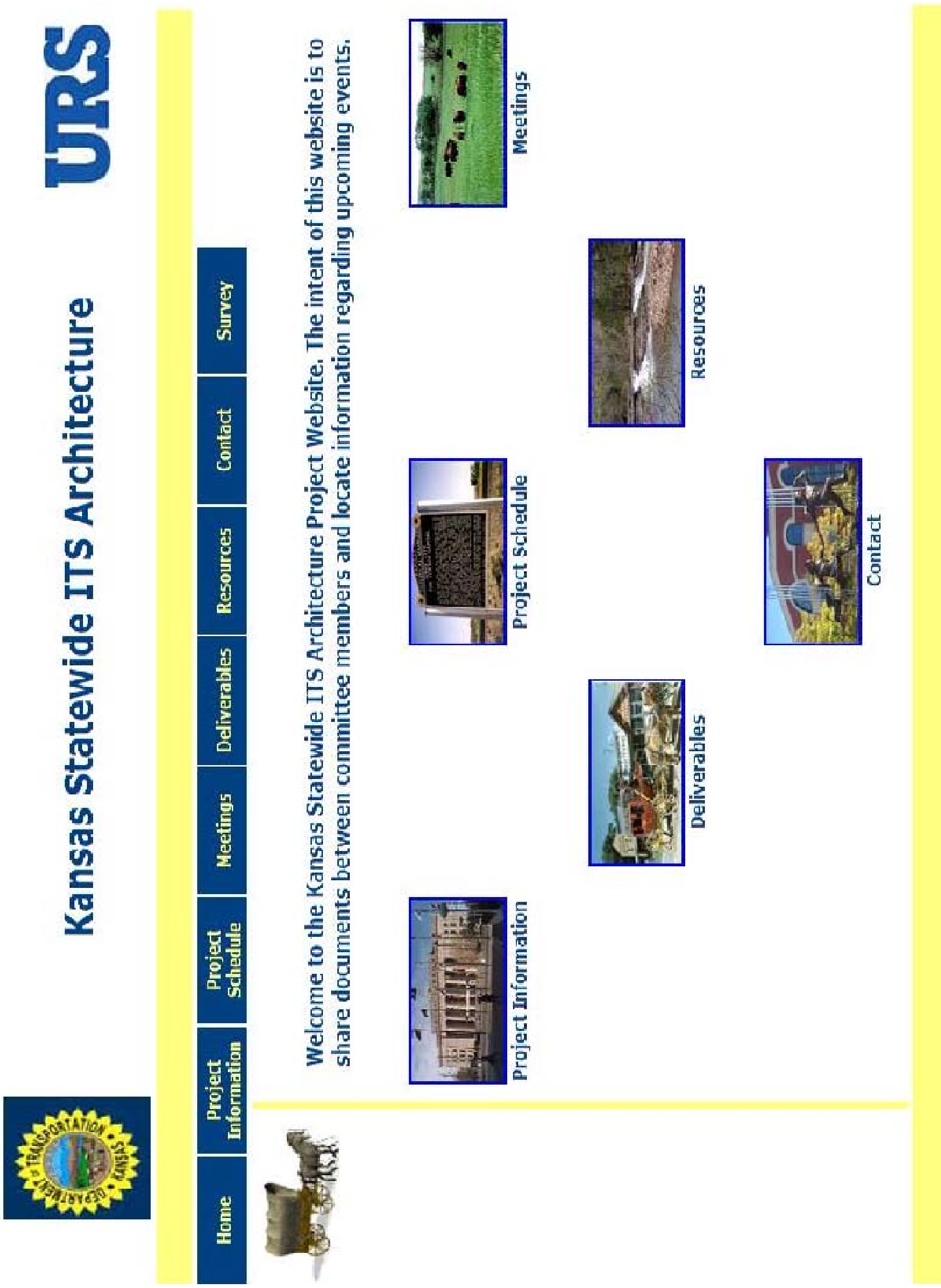
At the present time, KDOT policy is to only post weather related information. The discussion to expand this to include incident/lane closure messaging is currently being addressed by KDOT's ITS executive staff. A 7a-8p, 2-person staffed "virtual" TMC is being co-located in Wichita within the city's E911 communications center. After normal business hours, the 911 center operators have been cross-trained on the MIST™ application, if needed. Scout will serve as a secondary source for activating message boards. Each KDOT District is responsible for maintaining its' own hardware components (DMS & CCTVs). Consistency among districts with regard to messaging content is currently under review by KDOT management.

The success of weather messaging along the I-70 corridor in Kansas is dependent upon a uniform set of message guidelines which is presently lacking among the six Districts in the state. KC Scout's six years of experience with incident messaging is aiding in this dialogue between the rural and urban districts. The added component of integrated weather information into Scout's core ATMS operating system is something KDOT is monitoring closely, as reflected by their participation with the Project effort.

The I-70 Corridor has been studied by KDOT since early 2000 and various websites refer to active and planned projects.



Source: www.**ksdot**.org/burtransplan/mcsesummary.pdf



Source: http://kdotarchitecture.ursprojects.com/

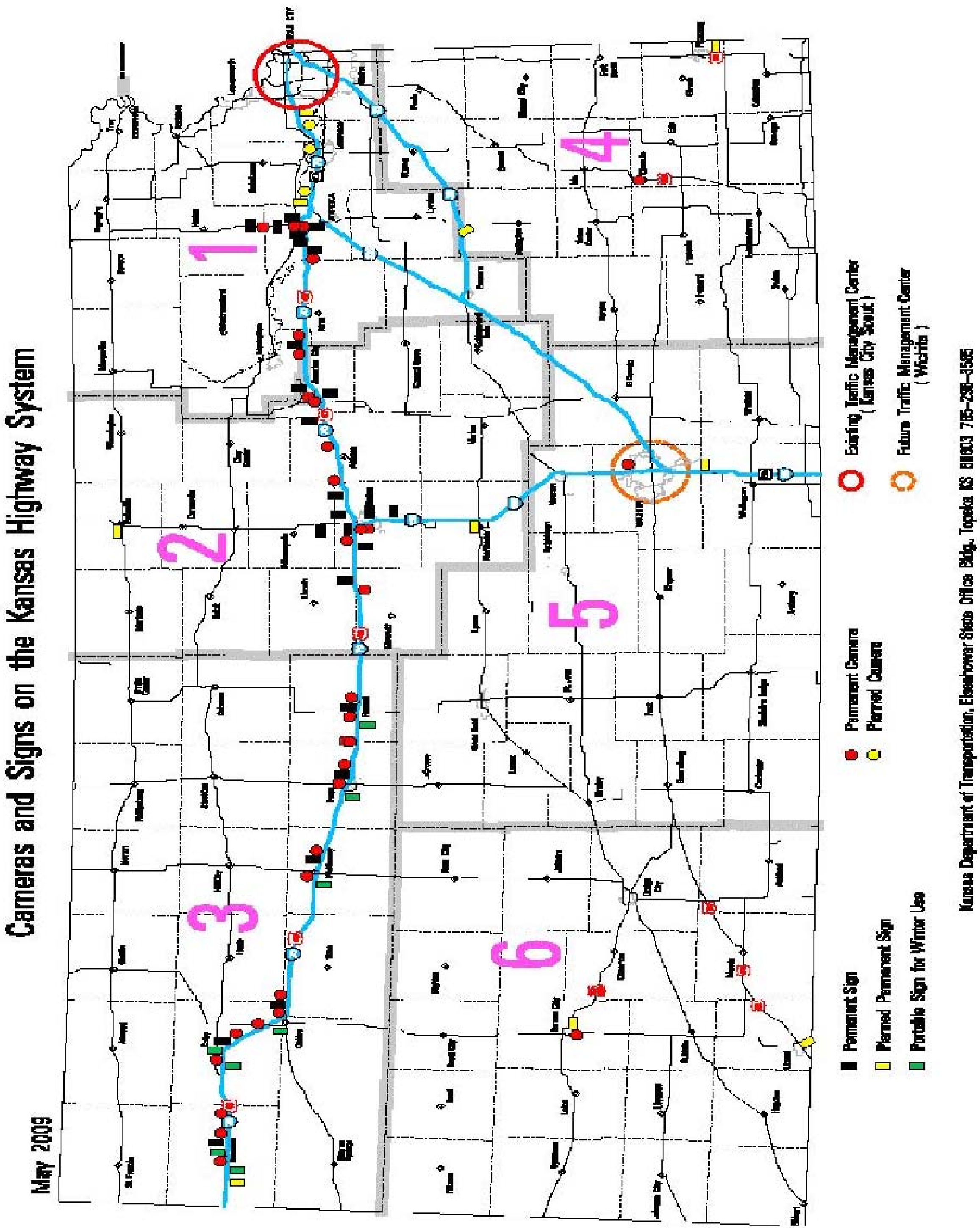


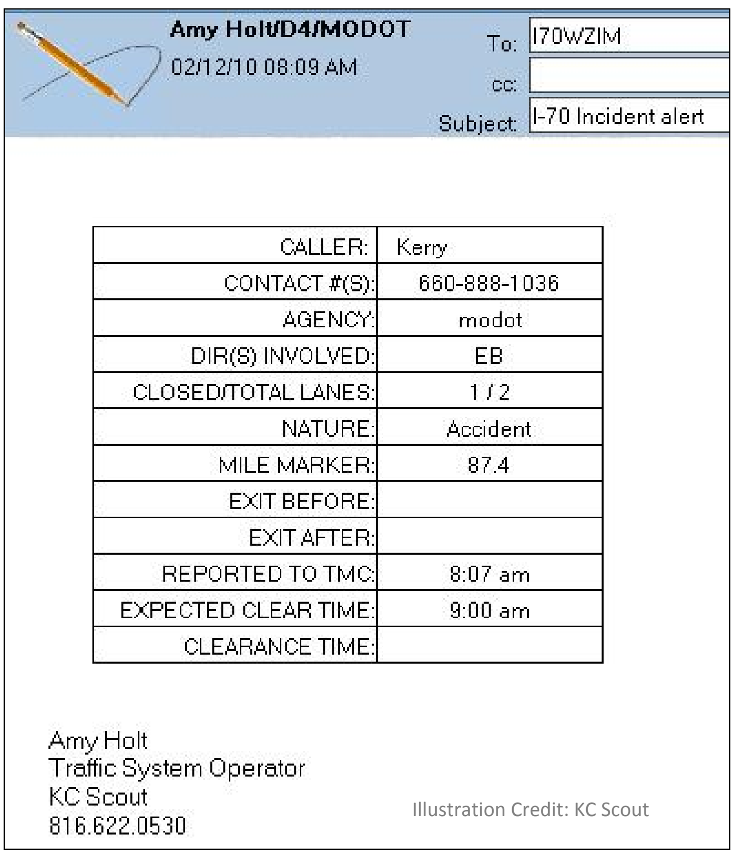
Figure 8.3.4 KDOT ITS Deployment Map Illustration Credit: Kansas Department of Transportation May 2009

8.3.6 Inter-Agency Coordination

In an ongoing effort to build relationships with other ITS Heartland agencies, a kick-off meeting was held at the TMC on January 22, 2010, attended by representatives from Scout, KDOT, NDOR (Nebraska Department of Roads) and the cities of Omaha, NE and Topeka, KS. To help formalize this process, KC Scout hired a consultant to assist with the planned Regional CAD Integration effort scheduled to begin in April 2010. Additionally, this individual will help coordinate scheduled conference calls, arrange 2-3 hour informational seminars and participate with Scout in ITS Heartland activities and Scout's own annual ITS Symposium, scheduled in conjunction with this year's MoVITE Conference on April 29, 2010 in downtown KC.

Point-of-contact email distribution lists are being developed so that TMCs can easily notify key personnel in neighboring jurisdictions whenever weather events occur, enabling proactive advance messaging to aid travelers leaving one region for another. As an example, KC Scout currently uses a simple email generated form sent to predefined list members whenever lane closures occur along the I-70, I-35 and I-29 corridors in Missouri. This reduces the number of phone call attempts and assures that the information reaches appropriate personnel in a timely manner.

Figure 8.3.5 Sample Email Incident Notification Alert



Amy Holt/D4/MODOT
02/12/10 08:09 AM

To: I70WZIM
cc:
Subject: I-70 Incident alert

CALLER:	Kerry
CONTACT #(S):	660-888-1036
AGENCY:	modot
DIR(S) INVOLVED:	EB
CLOSED/TOTAL LANES:	1 / 2
NATURE:	Accident
MILE MARKER:	87.4
EXIT BEFORE:	
EXIT AFTER:	
REPORTED TO TMC:	8:07 am
EXPECTED CLEAR TIME:	9:00 am
CLEARANCE TIME:	

Amy Holt
Traffic System Operator
KC Scout
816.622.0530

Illustration Credit: KC Scout

8.3.7 Development of Policies and Procedures

Implementing weather integration into standard TMC operations will involve the identification of new weather data elements integrated into the ATMS map layer. These various Common Alerting Protocol (CAP) tags have been incorporated into the April 2010 TransSuite™ software update. Discussion is underway to define weather event "thresholds" such as "wind gusts above 40 mph" which would trigger the ATMS map layer to display a polygonal reference of affected lat/long coordinates. Operators will then initiate a weather "event" with appropriate DMS messaging. Standard weather message sets are being developed and incorporated into the TransSuite™ Event Management module so that operators will only have to "accept" the proposed message to have it display correctly. Similarly, the ATMS will generate alert messages for the Scout Website and MyKCScout subscribers.

Efforts are underway to also incorporate available Clarus™ weather data XML elements as currently provided by KDOT's Meridian 511™ system. The data transfer protocols are being reviewed by Scout's software developers and likely will be included in the fall 2010 software update.

Operator Handbooks will need to be updated accordingly to reflect weather integration. Training modules within the Operator Certification Process will also need to be created to support end-user training.

8.4 Additional Impacts On Existing TMC Operations As a Result of Weather Integration Efforts

Staffing, support and training have been discussed within each strategy and are components of business-as-usual within the TMC. What is not so well understood are the communication costs and data storage ramifications of implementing new levels of weather information integration. If the data is available, Scout will be expected to report on it. Only by having true measurement criteria, can the success of any project be determined.

Where known, cost estimates have been included within the previous sections as pertains to each integration strategy/solution. Various initiatives are already underway with no cost impacts to Scout's TMC budget. Our operators have become accustomed to taking on increasing levels of responsibility. It is Scout management's task to see that training keeps up with the deployment of newer technology and system expansion. With implementation comes the added cost of supporting these new information platforms. Those cost estimates will need to be further investigated but are not seen as deterrents to moving forward with weather integration. The benefits far outweigh the costs.

9.0 OPERATIONS AND MAINTENANCE REQUIREMENTS

The operations and maintenance requirements of the planned weather integration activities defined in this document are expected to have minimal impact and will be addressed by existing activities and staff. The O&M

requirements on the technological integration into Scout's software will be handled by existing agreements with our software vendor and by Scout IT staff. The additional RWIS deployments planned will be a part of an existing network. Maintenance crews that currently service the existing RWIS will be tasked with adding these new devices to their existing list of stations.

10.0 ANTICIPATED CHALLENGES AND CONSTRAINTS OF INTEGRATION

The implementation tasks described in this document are currently underway. Momentum is building to continue finding ways to improve the delivery of services. Information technology is providing the means to continue growth of our ITS infrastructure. Funding has been appropriated to move these projects forward. The challenges and constraints faced by KC Scout as we move forward with implementation of this Weather Integration Plan include budgets, staffing, related schedule impacts, and technology integration.

Departments of Transportation are not immune to the effects of a recession economy. In November of 2009, MoDOT and KDOT both faced severe financial constraints as a result of the downturn. Organizations like KC Scout can struggle to balance shifting priorities, budget constraints, schedule delays, changes in leadership, and the need to juggle numerous initiatives to meet deadlines and avoid penalties. These conditions may place challenges on implementing the weather integration activities defined in this document. Additionally, KC Scout has only two shift supervisors responsible for 24/7 operations, and at times it becomes necessary to juggle project activity with floor supervision. Further, the Missouri statewide rural deployment of 69 CCTVs on major state highways will impact Scout by its having "after-hours support" capability due to our being one of two 24X7 TMCs in the entire state.

The constraints of any organizational integration effort are doubled in the case of KC Scout since our direction comes from not one, but two state departments of transportation. KDOT sustained the same types of funding shortfalls, and some ITS projects were put on "temporary hold" including the planned TMC in Wichita and DMS deployment on the I-70 corridor. Funding was cut for ITS expansion projects within KDOT as recently as March 5, 2010.

KC Scout may also encounter roadblocks having to do with technology issues. MoDOT's IT department recently moved forward with NGD (Next Generation Desktop) deployment of Microsoft Windows 7 and issues continue to arise involving compatibility with older legacy systems. Technology integration challenges may be faced by our ATMS software developer/vendor to deliver the planned upgrades to accommodate weather data integration in the next software upgrade scheduled for April 2010.

11.0 APPENDIX – KC SCOUT WEATHER INTEGRATION PLAN

APPENDIX

KC Scout Weather Integration Plan

Self-Evaluation Guide Reports

11.1 APPENDIX A – SUMMARY REPORT OF WEATHER EXPERIENCED EVENTS

Summary report of weather events experienced by your TMC (Section 1 Report)

Weather Event	Frequency	Extent	Impact
Blizzard or White-out	Seldom	Regional	Significant Impact
High Winds	Seldom	Areawide	Little Impact
Temperature Extremes	Occasional	Regional	Little Impact
Tornadoes	Occasional	Local/Isolated Spots	Moderate Impact
Blowing Snow	Regular	Areawide	Moderate Impact
Bridge Frost, Road Frost	Regular	Regional	Moderate Impact
Drizzle and Light Rain	Regular	Regional	Little Impact
Flooding	Regular	Local/Isolated Spots	Significant Impact
Flurries and Light Snow	Regular	Areawide	Moderate Impact
Moderate to Heavy Rain	Regular	Areawide	Moderate Impact
Moderate to Heavy Snow	Regular	Local/Isolated Spots	Significant Impact
Severe Thunderstorms	Regular	Local/Isolated Spots	Significant Impact
Sleet, and Freezing Rain	Regular	Local/Isolated Spots	Significant Impact
Smoke, Mist, Fog, Smog or Haze	Regular	Areawide	Little Impact

11.2 APPENDIX B – SUMMARY REPORT OF IMPACTS DUE TO WEATHER EVENTS

Summary report of impacts due to your weather events (Section 2 Report)

Weather often impacts the activities of transportation system operators working to maintain safety and mobility. Making sense of weather information along with recognizing the benefits of its application beyond the simplest case is not a trivial task. As a generalization, TMC operators tend to be more responsive and take action based on their observations of traffic impacts rather than responding directly to weather information. It is important to understand the nature of weather impacts on capacity and speed reductions, impacts on safety (e.g., crash risk/frequency, incident management including Safety Service Patrols that are often dispatched from or coordinated with TMCs), and impacts on institutional coordination (i.e., need for communication between traffic managers and maintenance personnel, traffic managers and emergency management personnel, traffic managers and law enforcement personnel) to ensure that the self-evaluation and the integration solutions address the right concerns. The ability to estimate impacts could presumably lead to managing freeway systems and arterial signal systems using advisory, control and treatment strategies efficiently.

This report identifies the impacts of these weather events on your TMC's traffic operations considering both impacts to users as well as operators

Traffic impacts commonly associated with the weather events in your region.

Weather Event	Increased Travel Times	Increased Crash Risk	Reduced Roadway Capacity	Traffic Management Device Impairment	Disruption of CVO or specialized vehicle operations	Road Closures
Drizzle and Light Rain	☐	☑	☐	☐	☐	☐
Moderate to Heavy Rain	☑	☑	☑	☑	☐	☐
Severe Thunderstorms	☑	☑	☑	☑	☑	☐
Flooding	☑	☑	☑	☑	☑	☑
Flurries and Light Snow	☑	☑	☐	☐	☐	☐

Moderate to Heavy Snow	☑	☑	☑	☑	☐	☐
Blizzard or White-out	☑	☑	☑	☑	☑	☑
Sleet, and Freezing Rain	☑	☑	☑	☑	☐	☐
High Winds	☐	☐	☐	☑	☑	☐
Blowing Snow	☑	☑	☑	☑	☐	☐
Smoke, Mist, Fog, Smog or Haze	☑	☑	☑	☑	☐	☐
Tornadoes	☐	☐	☐	☐	☑	☐
Temperature Extremes	☐	☐	☐	☑	☐	☐
Bridge Frost, Road Frost	☑	☑	☑	☐	☑	☐

Roadway impacts commonly associated with the weather events in the region

Weather Event	Slick Roads	Road Obstruction/ submersion	Structural deterioration	Presence of debris	Low visibility	Others (Please specify)
Drizzle and Light Rain	☑	☐	☐	☐	☐	
Moderate to Heavy Rain	☑	☑	☐	☐	☑	
Severe Thunderstorms	☑	☑	☐	☑	☑	

Traffic impacts commonly associated with the weather events in your region (cont.)

Weather Event	Increased Travel Times	Increased Crash Risk	Reduced Roadway Capacity	Traffic Management Device Impairment	Disruption of CVO or specialized vehicle operations	Road Closures
Flooding	☑	☑	☑	☑	☑	
Flurries and Light Snow	☑	☐	☐	☐	☐	
Moderate to Heavy Snow	☑	☑	☐	☐	☑	
Blizzard or White-out	☑	☑	☐	☐	☑	
Sleet, and Freezing Rain	☑	☑	☐	☐	☑	
High Winds	☐	☐	☑	☑	☐	
Blowing Snow	☑	☑	☐	☐	☑	
Smoke, Mist, Fog, Smog or Haze	☐	☐	☐	☐	☑	
Tornadoes	☐	☐	☑	☑	☐	
Temperature Extremes	☐	☐	☑	☐	☐	
Bridge Frost, Road Frost	☑	☐	☐	☐	☐	

Specific impacts of weather events in your region on TMC operations

LEGEND
4 - Significant Impact, 3 - Moderate Impact, 2- Little Impact, 1 - No Impact

Weather Event	Increased use of equipment and labor	Increased in-house labor	Increased contractor labor	Loss of communications /power	Changes in traffic control operations	Others Significant Impacts(Please specify)
Drizzle and Light Rain	2	1	1	1	1	
Moderate to Heavy Rain	3	1	1	2	1	
Severe Thunderstorms	3	2	2	3	1	
Flooding	3	3	2	2	3	
Flurries and Light Snow	2	1	1	1	1	
Moderate to Heavy Snow	4	3	2	2	3	
Blizzard or White-out	4	3	2	2	4	
Sleet, and Freezing Rain	4	3	2	3	3	
High Winds	2	2	1	2	1	
Blowing Snow	3	2	1	1	2	
Smoke, Mist, Fog, Smog or Haze	3	1	1	1	1	
Tornadoes	2	1	1	2	2	
Temperature Extremes	1	1	1	2	1	
Bridge Frost, Road Frost	2	1	1	1	2	

11.3 APPENDIX C – SUMMARY REPORT OF CURRENT LEVEL OF WEATHER INTEGRATION

Summary report on your TMC's current level of weather integration (Section 3 Report)

Item of Integration I1 Use of Internal Weather Information Resources

☐	☑	☑	☐	☐	☐
None	Camera imagery	Radar, satellite, ASOS and AWOS data, and general zone-type forecast information	Level 2 data plus data from RWIS and related networks	Level 3 data plus data from AVL/MDC sources and internal radio communications	Level 4 data with addition of analyzed fields and transformed data parameters (frost index, wind chill, est. snow, ice, water depth)

Item of Integration I2 Use of External Weather Information Sources

☐	☑	☑	☐	☐	☐
None	General weather information, forecasts, and interpretation provided through media as irregular service (radio and TV weather)	Internet provided, public access general forecasts, weather radar or satellite image or weather-specific broadcast channel	Field observers or probes providing scheduled weather / driving condition information from entire route system	Contractor provided surface transportation weather forecasts targeted at the operational needs of the TMC agencies	Direct connection between private weather information service providers and traffic management software

Item of Integration I3 Availablility of Weather Information

☐	☐	☑	☐	☐	☐
None	Cable channel or subscription weather information vendor providing general weather information	Internet provided weather radar or satellite image on video wall or computer screen	Field observers or ESS network providing scheduled road or driving condition reports	Vendor provided daily surface transportation weather forecasts and observed weather conditions including level 3.	Meteorologist, located within TMC, forecasting and interpreting weather

Item of Integration I4 Frequency of Weather Forecasts

☐	☑	☑	☑	☑	☑
None	Receive information of weather forecasts on a request basis	Receive weather forecast once daily.	Receive periodic forecasts several times a day	Receive hourly updates of weather forecasts several times a day	Receive continuous updates of weather forecasts in real-time

Item of Integration I5 Frequency of Weather/Road Weather

☐	☑	☑	☑	☐	☐
None	Receive information of weather conditions on a request basis	Receive weather observations once hourly	Level 2 plus receive weather/road weather observations when predefined thresholds have been exceeded	Receive weather/road weather observations every ten minutes and when predefined thresholds have been exceeded	Receive weather/road weather observations continuously with data above predefined thresholds highlighted

Item of Integration I6 Weather Information Coordination

☑	☐	☐	☐	☐	☐
None	Intra-TMC committee tasked with weather information coordination	Identified TMC or maintenance staff member tasked with coordinating weather information at TMC or virtually linked to the TMC	Dedicated weather operations supervisor	Meteorology staff located within the TMC forecasting and interpreting weather information	Co-location of the EOC/OEM

Item of Integration I7 Extent of Coverage

☑	☐	☐	☐	☐	☐
None	Sparse Set of Isolated Locations	Network of Scattered Locations	Corridor-level	Mulitple-corridor/sub-regional	Regional/Statewide

Item of Integration I8 Interaction with Meteorologists

☑	☐	☐	☐	☐	☐
None	Focus group or informal gatherings of local professionals from the transportation management and weather communities	Develop check list of routine weather awareness activities	Periodic staff meeting that includes a meteorologist to discuss weather information needs and responses	With a meteorologist present conduct post-event debriefing / regular assessment to fine-tune responses	Daily personal briefings and integrated interruptions by meteorology staff within the TMC

Item of Integration I9 Alert Notification

☐	☑	☐	☐	☐	☐
None	Monitor media outlet, Internet page, or data stream for critical events	Telephone call list	Manual email/paging system	TMC road weather system (RWIS / ALERT / FEWS) generated specific notifications (Email or page)	Automatic notification through Center-to-Center communications

Item of Integration II10 Decision Support

☐	☑	☐	☐	☐	☐
None	Ad-hoc implementation of weather management strategies	Use quick-reference flip cards on operator's workstation to implement predefined response	Response scenarios through software supply potential solutions with projected outcomes based on weather / traffic modeling	Automated condition recognition and advisory or control strategy presented to operator for acceptance into ATMS	Automated condition recognition and advisory or control strategy implemented without operator intervention

Item of Integration II11 Weather/Road Weather Data Acquisition

☐	☑	☑	☐	☐	☐
None	Media Reports	Internet and/or Satellite Data Sources	Across agency intranet and dedicated phone acquisition	Dedicated communications link to state, federal, private data sources	Dedicated communications link to state, federal, private data sources including vehicle-derived weather data

11.4 APPENDIX D – SUMMARY REPORT OF OPERATIONAL NEEDS

Summary report on your TMC operational needs that could be addressed by better weather integration (Section 4 Report)

Rating Legend: 3 – High, 2 – Medium, 1 - Low, 0 – No Need

Need Area

Rating	Need Statement

Advisory Operations

Rating	Need Statement
3-High	Disseminate weather information to a larger set of stakeholders and users in the region (including transit and other modes)
3-High	Provide better en-route information on weather conditions to aid travelers in their decision-making
2-Medium	Improve targeting of weather messages (site-specific; user group specific) to more effectively convey road weather information.
2-Medium	Improve message content (for DMS, 511, HAR, Web sites, etc.)
1-Low	Provide better pre-trip weather condition information to aid travelers in their decision-making

Institutional Coordination

Rating	Need Statement
3-High	Develop and implement clear, written policies and procedures for handling weather events.
2-Medium	More opportunities and mechanisms for communications and exchange with others in the weather community and those with experience dealing with weather events.
2-Medium	More coordinated responses and information with adjacent jurisdictions/regions
2-Medium	Improve coordination with local public safety and emergency agencies
1-Low	Improve coordination within the TMC

Traffic Control Operations

Rating	Need Statement
2-Medium	Improve traffic signal timing during weather events to facilitate traffic movement

1-Low	Improve management of emergency routing and evacuation for large-scale weather events
1-Low	Improve traffic diversion and alternate routing capabilities
0-No Need	Improve safety at intersections during weather events

Need Area

Rating	Need Statement

Treatment Operations

3-High	Improve the timeliness of weather management response including deployment of field personnel and equipment
1-Low	Reduce the time required to restore pre-event level of service operations after a weather event
0-No Need	Reduce costs of roadway treatment options
0-No Need	Need to assist maintenance in determining the optimal treatment materials, application rates, and timing of treatments.

Weather Information Processing and Gathering

3-High	Assistance in interpreting weather information and how best to adjust operations in light of that information.
3-High	Better real-time information on road conditions during weather events
2-Medium	Better prediction of impact of weather events including assessment of reductions in capacity
2-Medium	Better short-term forecasts of arrival time, duration, and intensity of specific weather events at specific locations
1-Low	Improve the coverage and granularity of weather information in the region

11.5 APPENDIX E– CURRENT INTEGRATION STRATEGIES REPORT

Current integration strategies – Report that describes in more detail integration strategies for your TMC's current level of weather integration (Section Report 5a)

Item of Integration	Use of Internal Weather Information Resources
Level	2
Title	Radar, satellite, ASOS and AWOS data, and general zone-type forecast information
Definition	This level of integration may provide TMC's with data on a local, regional, and/or statewide scale(s). Radar and satellite provide past and present data on possible precipitation over a designated region while ASOS and AWOS provide observations of conditions at precise, pre-determined locations. General zone-type forecast information gives TMC's a broad picture of possible weather events that may affect their region. These types of forecasts provide information on a region scale, including expected: •Maximum and minimum temperature •Average wind speed and direction •Cloud cover •Chance of precipitation within the region •Range of timing associated with precipitation

Complexity- Relative scale (High, Medium or Low) across the levels indicating the degree of difficulty in implementing this level

Low

Cost- Relative scale (High, Medium or Low) across the levels indicating the cost in implementing this level

Low

Requirements across the dimensions for strategy

Operational	•Use radar, satellite, ASOS/AWOS, and NWS zone forecast data within the TMC's operations. •Conduct staff training sessions on the characteristics of these weather information resources.
Physical	•Establish the communications link to the weather resource data •Procure any necessary equipment to process or display the weather data
Technical	•Determine the source of the weather data •Determine how the data will be processed internally •Determine whether the data will be displayed separately from camera imagery or via the same display mechanism

	•Develop or procure the necessary software to manage the data stream and permit operators to request and display the desired images or image loops
Procedural	•Define which ASOS/AWOS stations and zones are needed for operations •Establish procedures to restore data feed and processing if a break in acquisition occurs •Establish public relations material on use of weather information
Institutional	•Determine how management may acquire access to the weather data •Establish rules of practice regarding use of the weather data •Map out methods for integration of the weather information into existing or planned traffic management programs

Item of Integration	Use of External Weather Information Sources
Level	2
Title	Internet provided, public access general forecasts, weather radar or satellite image or weather-specific broadcast channel
Definition	Weather information at this level of integration provides weather data at regular intervals with information given in non-location-specific formats. Weather information at this level may be supplied to the TMC via the Internet through a private weather provider or through public forecasts. Forecasts provided are not tailored to the needs of the TMC but rather give a broad overview of conditions/forecasts within a given region.

Complexity- Relative scale (High, Medium or Low) across the levels indicating the degree of difficulty in implementing this level

Low

Cost- Relative scale (High, Medium or Low) across the levels indicating the cost in implementing this level

Low

Requirements across the dimensions for strategy

Operational	•Use radar, satellite, ASOS/AWOS, NWS zone forecasts, and media provided local forecast data to support TMC operations. •Conduct staff training sessions on the characteristics of these weather information resources and their use in operations.
Physical	•Establish the communications link to the weather resource data •Procure any necessary equipment to process or display the weather data
Technical	•Determine the source of the weather data •Determine how the data will be processed internally •Determine how the information will be displayed in the TMC operations center •Develop or procure the necessary software to manage the data stream and permit operators to request and display the desired images or image loops
Procedural	•Define which ASOS/AWOS stations and zones are needed for operations

	•Establish procedures to restore data feed and processing if a break in acquisition occurs •Establish public relations material on use of weather information in TMC operations
Institutional	•Determine how management may acquire access to the weather data •Establish rules of practice regarding use of the weather data •Map out methods for integration of the weather information into existing or planned traffic management programs

Item of Integration	Availablility of Weather Information
Level	2
Title	Internet provided weather radar or satellite images on video wall or computer screen
Definition	Weather radar and/or satellite imagery provides real-time weather information to TMCs through images displayed on the video wall within the operations center. Radar and satellite are continuously updated via the Internet which results in real-time information. None of this information is interpreted by the Internet; therefore weather information may be confusing or non-beneficial for the TMC's operations.

Complexity- Relative scale (High, Medium or Low) across the levels indicating the degree of difficulty in implementing this level

Low

Cost- Relative scale (High, Medium or Low) across the levels indicating the cost in implementing this level

Low

Requirements across the dimensions for strategy

Operational	•Weather information is viewed by TMC staff on facility monitors
Physical	•Set-up video wall to display radar and/or satellite
Technical	Minimal
Procedural	Minimal
Institutional	Minimal

Item of Integration	Frequency of Weather Forecasts
Level	4
Title	Receive hourly resolution weather forecasts several times a day

Definition This strategy extends the features of a daily detailed (hourly) weather forecast by permitting a refinement of the forecasted weather conditions several times a day with new hourly resolution forecasts. This permits the weather forecasts to respond to new weather observations and additional weather model projections. The value of these forecasts is in the detail afforded by the hourly resolution along with the updates during the day. TMC operations would use these forecasts to more frequently adjust to time critical variations in forecasted weather conditions.

Complexity- Relative scale (High, Medium or Low) across the levels indicating the degree of difficulty in implementing this level

Low

Cost- Relative scale (High, Medium or Low) across the levels indicating the cost in implementing this level

Medium

Requirements across the dimensions for strategy

Operational •Establish a method of including periodic forecast information within TMC operations that accounts for the updated information

Physical •Need an agency distribution system to provide notifications of forecast arrival and updates

Technical •Develop standard operating procedures for requesting a forecast

Procedural •Establish methods for reporting on the usefulness of weather forecasts at the frequency being received

Institutional •Need to identify TMC staff qualified to determine the frequency of weather forecasts needed

Item of Integration Frequency of Weather/Road Weather Observations

Level 3

Title Receive weather/road weather observations when predefined thresholds have been exceeded

Definition This strategy combines the standard hourly flow of weather observations to include road weather observations. Further, using thresholds predefined by TMC personnel to identify critical operational situations, the weather and road weather observations are provided when these thresholds are exceeded. This would enable TMC staff to quickly identify locations and weather situations that are most crucial to their decision making efforts.

Complexity- Relative scale (High, Medium or Low) across the levels indicating the degree of difficulty in implementing this level

Low

Cost- Relative scale (High, Medium or Low) across the levels indicating the cost in

implementing this level

Medium

Requirements across the dimensions for strategy

Operational	•Establish a method of including weather and road weather observations within TMC operations that accounts for the updated information •Define performance measures that assess the utilization of weather and road weather observations relative to the frequency of acquisition
Physical	•Need an agency distribution system to provide notifications of weather and road weather observations that exceed threshold values
Technical	•Define the frequency of weather and road weather observations needed and the appropriate delivery times
Procedural	•Establish methods for reporting on the usefulness of weather forecasts at the frequency being received
Institutional	•Define the administrative process to manage the flow of weather and road weather observations within the TMC infrastructure •Define the process to address quality issues associated with observation data

Item of Integration	Alert Notification
Level	1
Title	Monitor media outlet, Internet page, or data stream for critical events
Definition	In this strategy, TMC operators would simply monitor media outlets, Internet pages and other weather-related data streams to monitor when weather conditions at critical locations might justify a response. Under this strategy, weather information would be used solely by the TMC. The TMC might use this information to place messages on dynamic message signs, or highway advisory radio, but there would be no communications to external response providers (such as police or maintenance crews).

Complexity- Relative scale (High, Medium or Low) across the levels indicating the degree of difficulty in implementing this level

Low

Cost- Relative scale (High, Medium or Low) across the levels indicating the cost in implementing this level

Low

Requirements across the dimensions for strategy

Operational	Minimal
Physical	•Need access to external information source(s) (i.e. radio station, Internet, weather service provider)
Technical	Minimal

Procedural	•Develop standard operating procedures for monitoring of weather information by TMC operator
Institutional	Minimal

Item of Integration	Decision Support
Level	1
Title	Ad-hoc implementation of weather management strategies
Definition	Under this strategy, operators in the TMC manage the impacts of weather on traffic operations on an ad-hoc basis. Using detection and surveillance technologies, operators observe and monitor the effects and impacts that particular weather events have on traffic operations and adjust the advisory, control, and treatments responses based on these observations. TMC operations may have general knowledge about what types of responses to implement (based upon previous experience) but do not necessarily have any formalized, pre-planned responses to manage traffic during developing weather.

Complexity- Relative scale (High, Medium or Low) across the levels indicating the degree of difficulty in implementing this level

Low

Cost- Relative scale (High, Medium or Low) across the levels indicating the cost in implementing this level

Low

Requirements across the dimensions for strategy

Operational	•Establish "Weather triggers" as a baseline for TMC operators to implement appropriate ad-hoc responses.
Physical	•Need access to readily available weather information source(s) (i.e. cameras, radio station, Internet, weather service provider, filed sensors, etc.
Technical	Minimal
Procedural	•Ensure that TMC operators reacting to weather events on an ad-hoc basis do not overstep their authority or TMC procedures in implementing a specific response. •Develop a set of standard operating procedures for fine-tuning weather responses, including the recovery mechanism from an implemented ad-hoc response.
Institutional	Minimal

Item of Integration Weather/Road Weather Data Acquisition

Level 2

Title Internet and/or satellite data sources.

Definition In this strategy, TMC operators would acquire road-weather information from internet and/or satellite data sources. These sources can be from public or private weather information providers and allow the operator to continuously monitor developing conditions. Using satellite and Internet sources, operators can obtain predictions of when weather conditions, such as snow and heavy rainfall, might arrive at specific locations.

Complexity- Relative scale (High, Medium or Low) across the levels indicating the degree of difficulty in implementing this level

Low

Cost- Relative scale (High, Medium or Low) across the levels indicating the cost in implementing this level

Low

Requirements across the dimensions for strategy

Operational
•Monitor weather information from additional sources, such as Internet or satellite data feeds.
•Access weather forecasts / predictions on movement of weather systems.
•Enable forecast / prediction information to be passed on to other TMC subsystems.

Physical
•Secure ability to access Internet or satellite communications feed capability to access weather information.
•Install terminal in TMC for displaying weather information
•Integrate internet weather feeds into TMC displays

Technical Minimal

Procedural
•Obtain access to additional information sources such as public Internet feeds, private Internet streams, or satellite information.
•Set policies to allow operators to actively monitor weather information from these additional sources.

Institutional
•Provide funding to continue access to additional weather information sources.

11.6 APPENDIX F– INTEGRATION STRATEGIES TO MEET OPERATIONAL NEED

Report that describes integration strategies to meet the following TMC's selected operational needs. This is your integration target (Section 5b Report)

Item of Integration Use of Internal Weather Information Resources

Level 3

Title Level 2 data plus data from RWIS and related networks

Definition TMC's utilize all data sets within level 2 integration but also incorporate data from RWIS environmental sensor stations (ESS) and other weather networks that may be available for a given location. ESS provides TMC's with weather directly adjacent to the road allowing for a better understanding of weather conditions affecting the road surface and ultimately traffic. The ESS observations can include, but are typically limited to:
•Air temperature
•Relative humidity/dew point temperature
•Wind speed and direction
•Pavement surface temperature
•Pavement surface condition
•Chemical concentration or freeze point temperature

Complexity - Relative scale (High, Medium or Low) across the levels indicating the degree of difficulty in implementing this level

Medium

Cost - Relative scale (High, Medium or Low) across the levels indicating the cost of implementing this level

Medium

Requirements across the dimensions for strategy

Operational •Use RWIS and related data within TMC operations
•Conduct staff training sessions on the features of RWIS data and how to interpret their impact on traffic flow

Physical •Establish a communications link to a source of the RWIS data

Technical •Determine the source of the RWIS and related data
•Determine how the data will be processed internally
•Determine whether the data will be displayed separately from camera imagery or via the same display mechanism
•Develop or procure the necessary software to manage the data stream and permit

operators to request and display the data in the desired format

Procedural •Define which RWIS stations or other resources are necessary to support operations
•Establish procedures to restore RWIS data feed and processing if a break in acquisition occurs
•Establish public relations material on use of RWIS information

Institutional •Determine how management may acquire access to the RWIS data
•Establish rules of practice regarding use of RWIS data
•Map out methods for integration of RWIS data into existing or planned traffic management programs

Item of Integration Use of External Weather Information Sources

Level 4

Title Contractor provided surface transportation weather forecasts targeted at the operational needs of the TMC agencies

Definition This level of integration provides corridor level forecasting tailored to the needs of a TMC in an operational setting. The tailored forecasts are updated several times daily allowing TMCs to be aware of changing weather conditions that could affect traffic. TMCs are able to interact with the weather provider to request weather information for specific situations. This type of communications also permits the TMC representative to share guidance regarding how weather impacts TMC operations and how the weather provider can better support those needs. The forecasts received from the weather services provider will be much more detailed in nature than the information at the level 2 integration. This detail includes hour by hour forecasts of:
•Road conditions
•Pavement temperature
•Deck temperature
•Precipitation type
•Precipitation rate
•Precipitation start/end time
•General atmospheric parameters

Complexity - Relative scale (High, Medium or Low) across the levels indicating the degree of difficulty in implementing this level

Medium

Cost - Relative scale (High, Medium or Low) across the levels indicating the cost of implementing this level

High

Requirements across the dimensions for strategy

Operational •Use contractor-provided road weather information to support TMC operations
•Conduct staff training sessions on the characteristics of the contractor service

	elements and how to utilize these resources in operations
Physical	•Establish a communications link to a source of the post-processed weather data
Technical	•Integrate analysis products into the infrastructure developed for the previous levels of integration
Procedural	•Define which products need to be accessible in TMC •Establish procedures to restore access to data if a break in acquisition occurs •Establish public relations material on use of all levels of service and its benefit to TMC operations
Institutional	•Determine how management may acquire access to the entire suite of weather support information •Establish rules of practice regarding use of the weather support data •Map out methods for integration of the various weather resources into existing or planned traffic management programs

Item of Integration	Availablility of Weather Information
Level	4
Title	Vendor provided daily surface transportation weather forecasts and observed weather conditions including level 3
Definition	The availability of data is only limited to the number of weather observations and frequency of forecast updates. A meteorologist within the TMC will provide data as near real-time as possible to aid in traffic operations. The interpretation of forecast and observations by a trained meteorologist also allows for more information to be utilized by TMCs because weather information can be quickly relayed to traffic managers in a form they can understand.

Complexity - Relative scale (High, Medium or Low) across the levels indicating the degree of difficulty in implementing this level

Medium

Cost - Relative scale (High, Medium or Low) across the levels indicating the cost of implementing this level

High

Requirements across the dimensions for strategy

Operational	•Incorporate weather forecasts within TMC's
Physical	•Set-up video wall to display radar and/or satellite
Technical	Minimal
Procedural	•Provision of data in a tabulation of weather/driving conditions
Institutional	Minimal

Item of Integration Frequency of Weather Forecasts

Level 4

Title Receive hourly resolution weather forecasts several times a day

Definition This strategy extends the features of a daily detailed (hourly) weather forecast by permitting a refinement of the forecasted weather conditions several times a day with new hourly resolution forecasts. This permits the weather forecasts to respond to new weather observations and additional weather model projections. The value of these forecasts is in the detail afforded by the hourly resolution along with the updates during the day. TMC operations would use these forecasts to more frequently adjust to time critical variations in forecasted weather conditions.

Complexity - Relative scale (High, Medium or Low) across the levels indicating the degree of difficulty in implementing this level

Low

Cost - Relative scale (High, Medium or Low) across the levels indicating the cost of implementing this level

Medium

Requirements across the dimensions for strategy

Operational •Establish a method of including periodic forecast information within TMC operations that accounts for the updated information

Physical •Need an agency distribution system to provide notifications of forecast arrival and updates

Technical •Develop standard operating procedures for requesting a forecast

Procedural •Establish methods for reporting on the usefulness of weather forecasts at the frequency being received

Institutional •Need to identify TMC staff qualified to determine the frequency of weather forecasts needed

Item of Integration Frequency of Weather/Road Weather Observations

Level 3

Title Receive weather/road weather observations when predefined thresholds have been exceeded

Definition This strategy combines the standard hourly flow of weather observations to include road weather observations. Further, using thresholds predefined by TMC personnel to identify critical operational situations, the weather and road weather observations are provided when these thresholds are exceeded. This would enable TMC staff to quickly identify locations and weather situations that are most crucial to their decision making efforts.

Complexity - Relative scale (High, Medium or Low) across the levels indicating the degree of difficulty in implementing this level

Low

Cost - Relative scale (High, Medium or Low) across the levels indicating the cost of implementing this level

Medium

Requirements across the dimensions for strategy

Operational •Establish a method of including weather and road weather observations within TMC operations that accounts for the updated information
•Define performance measures that assess the utilization of weather and road weather observations relative to the frequency of acquisition

Physical •Need an agency distribution system to provide notifications of weather and road weather observations that exceed threshold values

Technical •Define the frequency of weather and road weather observations needed and the appropriate delivery times

Procedural •Establish methods for reporting on the usefulness of weather forecasts at the frequency being received

Institutional •Define the administrative process to manage the flow of weather and road weather observations within the TMC infrastructure
•Define the process to address quality issues associated with observation data\

Item of Integration Interaction with Meteorologists

Level 3

Title Periodic staff meeting that includes a meteorologist to discuss weather information needs and responses

Definition This strategy provides the opportunity for the TMC without a meteorology staff to discuss weather information needs and responses. This discussion permits meteorologists to provide an orientation on weather and road weather solutions that exist that could be considered by the TMC staff to improve the utilization of weather and road weather in TMC decision making. The participation of a meteorologist would be on an infrequent basis but possible with increasing frequency as the TMC improves its weather integration efforts.

Complexity - Relative scale (High, Medium or Low) across the levels indicating the degree of difficulty in implementing this level

Low

Cost - Relative scale (High, Medium or Low) across the levels indicating the cost of implementing this level

Low

Requirements across the dimensions for strategy

Operational
•Create a checklist of routine weather awareness activities
•Conduct periodic, scheduled meeting with staff to discuss weather information needs and responses with meteorologist participation

Physical
•Provide information message and notification system that facilitates rapid-responses between traffic management staff and meteorologists (in-house and external)

Technical
•Active listserve for exchange of coordination information

Procedural
•Develop protocols for addressing weather related traffic management issues with the weather community
•Develop a procedure for identifying weather-related events that require a post-event debriefing

Institutional
•TMC administrative support for staff (and administrators) to engage in dialog with the weather and surface transportation weather communities

Item of Integration Alert Notification

Level 4

Title TMC road weather system (RWIS / ALERT / FEWS) generated specific notifications (Email or page)-

Definition
With this strategy, weather related alerts are sent to key response personnel on the call list automatically by road weather monitoring equipment. The systems would send the emails or pages directly to response personnel, replacing the need for the TMC operator to formulate a specific message. The TMC would need to develop the structure and format of the messages. Depending upon the type of road weather monitoring system installed within particular locations, responders can receive detailed weather information, including the following:
•Air temperature;
•Dew point or relative humidity;
•Precipitation occurrence, type and intensity;
•Precipitation accumulation and water level;
•Wind speed and direction;
•Visibility distance; and
•Pavement temperature, freezing point, condition, and chemical concentration

Complexity - Relative scale (High, Medium or Low) across the levels indicating the degree of difficulty in implementing this level

High

Cost - Relative scale (High, Medium or Low) across the levels indicating the cost of implementing this level

High

Requirements across the dimensions for strategy

Operational

•Automate weather alerts from RWIS or similar systems to TMC operators
•Define level of operator interaction (i.e approval required) for automated messaging of weather alerts
•Identify field devices and locations for data collection to support weather alert systems.
•Establish integrity of field data reporting systems and integration into TMC system software

Physical

•Establish infrastructure to support high-end systems, such as automatic notifications or C2C.
•Identify resource requirements for weather-related components
•Establish communication pathway between weather system components and TMC
•Determine hardware and software components necessary to accomplish integration of weather alerts and TMC software.

Technical

•Define data flows for weather information between field devices, software systems and TMC personnel.
•Establish display and update requirements for visual display of weather information or alerts within TMC operator station
•Establish communication protocols and message set standards for road weather information systems or similar devices
•Identify data elements, and storage mechanism for retaining information to generate performance measures
•Define interface requirements between systems sharing weather information.
•Establish a C2C infrastructure with identified agencies for sharing information, including weather alerts

Procedural

•Define TMC operator responsibilities within the weather alert notification system

Institutional

•Establish MOU / Inter-agency agreement to allow for joint monitoring of field devices by multiple agencies.

Item of Integration Decision Support

Level 3

Title Response scenarios are supplied through software that identifies potential solutions with projected outcomes based on weather/traffic modeling

Definition Under this strategy, a decision support tool would be developed that would allow the operator to generate potential advisory, control, and treatment responses based upon information about developing weather conditions. This decision support tool would incorporate criteria and triggers for different types of agency responses. The operator would be required to enter specific information about a developing weather event through an interface, and the system would then identify potential solutions and strategies based on a predefined set of “rules” or desired responses. Under this strategy, the operator would have the primary responsibility of both entering the appropriate weather information and implementing the appropriate advisory, control and treatment responses.

Complexity - Relative scale (High, Medium or Low) across the levels indicating the degree of difficulty in implementing this level

Medium

Cost - Relative scale (High, Medium or Low) across the levels indicating the cost of implementing this level

Medium

Requirements across the dimensions for strategy

Operational •Train TMC operators in implementation of pre-defined sequences, focusing on data sources, trigger points, and follow-up actions.

Physical •Operator needs to view weather information sources and have available interface for data entry into decision support system.

Technical •Develop system architecture to allow for weather data entry and analysis.
•Develop algorithm for generating suggested system response to weather events.

•Create visual interface into system data for TMC operator viewing / analysis.
•Establish support systems to ensure data quality and resolve conflicting

Procedural •Develop a standard set of triggers which would cause an operator to initiate use of the decision support system.
•Develop standard rules and policies for implementing suggested response to weather triggers.

Institutional •Develop inter-agency agreement to allow for the joint operation of traffic management infrastructure in the implementation of responses to weather events.

Item of Integration Weather/Road Weather Data Acquisition

Level 3

Title Across agency intranet and dedicated phone acquisition

Definition With this strategy, TMC operators would access their weather information not only from external sources, but agency owned and operated weather monitoring stations to acquire road-weather information. Weather monitoring devices would be installed at strategic locations and would allow the operator to access detailed weather information from specific locations. Depending upon the extent of coverage, information could be from scattered locations to region or area-wide. This level requires a more extensive communications network to bring back the weather information from the remote sensors to the TMC.

Complexity - Relative scale (High, Medium or Low) across the levels indicating the degree of difficulty in implementing this level

Medium

Cost - Relative scale (High, Medium or Low) across the levels indicating the cost of implementing this level

Medium

Requirements across the dimensions for strategy

Operational	•Develop algorithms that monitor agency owned and operated weather information sources on a periodic basis.
Physical	•Procure and install system of agency owned and operated weather information sources. •Integrate data feed with TMC software •Provide an on-going communications capability to each information source.
Technical	•Establish or adopt communications protocols for transmitting weather information •Establish or adopt standard message sets for weather information transmission
Procedural	•Set policies on the use of agency specific field information sources.
Institutional	•Provide funding to construct and maintain a field network of weather information sources.

11.7 APPENDIX G– INTEGRATION STRATEGIES TO MEET TARGET NEEDS

Report that describes integration strategies between where you are now and where you want to be. This describes steps to get to your target level of integration (Section 5c Report)

Item of Integration Use of External Weather Information Sources

Level 3

Title Field observation or probes providing scheduled weather / driving condition information from entire route system

Definition Road/weather information is reported to TMCs on scheduled intervals from field observations or instrumentation located within the right-of-way or roadway environment. The reports provide weather information that covers all routes within the TMC's jurisdiction to aid in decision making processes. These data include:

•Road conditions
•Current weather conditions
•Past weather conditions

Complexity- Relative scale (High, Medium or Low) across the levels indicating the degree of difficulty in implementing this level

Medium

Cost - Relative scale (High, Medium or Low) across the levels indicating the cost of implementing this level

Medium

Requirements across the dimensions for strategy

Operational •Use route specific (RWIS or MDC) data within TMC operations
•Conduct staff training sessions on the features of RWIS data and how to interpret their impact on traffic management.

Physical •Establish a communications link to a source of the RWIS, MDC, or related field data

Technical •Determine the source of the RWIS, MDC, and/or related data
•Determine how the data will be processed internally
•Develop or procure the necessary software to manage the data stream and permit operators to request and display the data in the desired format

Procedural •Define which RWIS stations, MDC routes, or other resources are necessary to support operations
•Establish procedures to restore RWIS data feed and processing if a break in acquisition occurs
•Establish public relations material on use of RWIS and/or MDC information to support TMC operations

Institutional	•Determine how management may acquire access to the RWIS, MDC, or related data •Establish rules of practice regarding use of this data •Map out methods for integration of RWIS and MDC data into existing or planned traffic management programs

Item of Integration	Availablility of Weather Information
Level	3
Title	Field observers or ESS network providing scheduled road or driving condition reports
Definition	Field observations or ESS networks provide data when weather information is needed. The availability of data is as needed or on a scheduled basis. The data can be collected from field observers on a schedule throughout the day or when weather may be affecting the route network. ESS can be scheduled to deliver data on a regular schedule or when thresholds are met by sensors and data are sent back to the TMCs.

Complexity- Relative scale (High, Medium or Low) across the levels indicating the degree of difficulty in implementing this level

Medium

Cost - Relative scale (High, Medium or Low) across the levels indicating the cost of implementing this level

Medium

Requirements across the dimensions for strategy

Operational	•Establish locations for field observers to take observations •Identify locations for ESS deployment
Physical	•Set-up video wall to display radar and/or satellite
Technical	Minimal
Procedural	•Provision of data in a tabulation of weather/driving conditions
Institutional	Minimal

Item of Integration	Weather Information Coordination
Level	1
Title	Intra-TMC committee tasked with weather information coordination
Definition	This strategy provides a rudimentary process to incorporate weather information into the work environment within a TMC. Formation of a local committee provides a central structure to address weather information-related TMC activities

and foster discussions to identify weather / road weather needs and methods to address these needs. This effort would most likely not include any external or internal meteorologist input.

Complexity- Relative scale (High, Medium or Low) across the levels indicating the degree of difficulty in implementing this level

Low

Cost - Relative scale (High, Medium or Low) across the levels indicating the cost of implementing this level

Low

Requirements across the dimensions for strategy

Operational	•Establish lines of communications between the TMC and identified meteorologists •Establish an email list of points-of-contact in the weather community •Periodic staff meetings to discuss weather information needs
Physical	•Construct a database of contacts within the TMC and weather community who will be involved in interaction efforts
Technical	•Email communication between TMC staff and weather staff and advisors
Procedural	Minimal
Institutional	•Seek advice of weather consultant

Item of Integration	Weather Information Coordination
Level	2
Title	Identified TMC or maintenance staff member tasked with coordinating weather information at TMC or virtually linked to TMC
Definition	This strategy would possible build upon an intra-TMC weather information coordination committee with a staff member assigned to coordinate weather information activities within the TMC. Or this could be a single staff member assigned to explore the same issues as the intra-TMC committee with an additional responsibility to perform ongoing efforts to better identify and address weather needs. This would be an individual either with a partial or full-time assignment to coordinate TMC weather information.

Complexity- Relative scale (High, Medium or Low) across the levels indicating the degree of difficulty in implementing this level

Low

Cost - Relative scale (High, Medium or Low) across the levels indicating the cost of implementing this level

Low

Requirements across the dimensions for strategy

Operational •Exchange weather issues of interest using a local TMC managed list-serve that includes both TMC staff and in-house and external weather staff
•Create a list of contacts with associated regions of weather expertise of importance to the TMC activities
•Provide routine orientation briefings of TMC staff on weather information availability and seek staff input on needs
•Local forums are held between TMC staff and local meteorological community
•Acquire staff training on weather/road weather information

Physical •Provide communications interface that links weather supervisor with TMC supervisory personnel
•Provide communications support for in-house meteorology staff that provides effective exchanges of information between traffic management activities and meteorological analysis and forecast activities.

Technical •Active listserve for exchange of coordination information

Procedural •Develop a checklist of routine weather awareness activities to conduct with staff

Institutional •Seek advice of weather consultant

Item of Integration Extent of Coverage

Level 1

Title Expand the extent of coverage of weather information to include a sparse set of isolated locations

Definition This strategy involves the collection of weather information from a set of isolated locations known to be impacted by severe weather. Examples of potential locations include low water crossings, bridges, mountain passes, etc. Generally weather information would be generated from agency-owned weather monitoring stations. These stations may be attached directly to specific traffic advisory, control, and treatment devices as stand-alone systems. Traffic advisory, control, and treatment responses would be designed to address weather-related impacts at those specific locations only.

Complexity- Relative scale (High, Medium or Low) across the levels indicating the degree of difficulty in implementing this level

Low

Cost - Relative scale (High, Medium or Low) across the levels indicating the cost of implementing this level

Low

Requirements across the dimensions for strategy

Operational •Establish “sensor triggers” to notify TMCs when specific sensors or stations have reported activity which indicates a weather condition.
•If triggered sensors at specific locations are not tied to an alert mechanism, TMC should issue a point specific alert.

Physical	•At minimum, need an accessible communications link to each information source.
Technical	•Determine the data reporting parameters and message components of each sensor type to insure information is captured accurately.
Procedural	•Develop standard operating procedures for monitoring of sensor network by TMC operator. •Establish appropriate procedures for monitoring the health of sensor and communication systems.
Institutional	•Obtain permission from appropriate agencies to place sensors at strategic locations. •Identify funding sources for procuring systems, maintenance and operations, and regular and recurring training for field sensors systems.

Item of Integration	Extent of Coverage
Level	2
Title	Expand the extent of coverage to a network of sensors from scattered locations
Definition	Instead of obtaining weather information from one or two isolated locations, weather information would be obtained from a network of strategically-located sites (5 to 10 locations) scattered throughout a region or urban region. The purpose of this network of sites would be to obtain a general overview of the weather conditions. The TMC operator would be able to use the information from the network to monitor the path and extent of changing weather conditions as well as to make strategic decisions for distributing resources and personnel. Information from these locations could also be used to provide advisory information via a web-site. Devices used to provide information would primarily be owned by the operating agency; however, agencies might consider integrating information from privately-owned devices, or devices owned by other operating agencies to complete the network or to fill in holes were information is missing.

Complexity- Relative scale (High, Medium or Low) across the levels indicating the degree of difficulty in implementing this level

Medium

Cost - Relative scale (High, Medium or Low) across the levels indicating the cost of implementing this level

Medium

Requirements across the dimensions for strategy

Operational	•TMC to use weather information from sensor network to issue general advisory statements, using standard information dissemination capabilities such as DMS and web sites.
Physical	•Need to establish a standardized reporting or polling scheme for system sensors to transfer information to TMC on a routine basis. •Need to establish a “back room” infrastructure to support the polling / reporting

process to system sensors.
•Obtain access to external information source(s) (i.e. radio station, Internet, weather service provider) to expand system sources of information.
•Need to develop infrastructure capable of sharing sensor system alerts to appropriate agencies.

Technical •Need to establish an analysis routine of system data which can monitor the path and extent of changing weather conditions based on sensor reports.]

Procedural •Develop standard operating procedures for internal and external notification of sensor alerts.
•Develop standard procedures for keeping information dissemination methods updated (media, web, etc).
•Establish mechanisms for reporting on the effectiveness and timeliness of weather-related TMC alerts.

Institutional •Develop data sharing agreement with appropriate agencies to allow access to sensors at additional strategic locations.
•Establish MOU / Inter-agency agreement to allow for joint monitoring of field devices by multiple agencies.
•Define the level of commitment and partnership between agencies for participating in systems for weather alert notifications.

Item of Integration Extent of Coverage

Level 3

Title Expand the extent of coverage to a network of sensors to provide corridor-level weather information

Definition In this strategy, an agency would expand the coverage of weather information devices that provides information about weather conditions from multiple locations in a specific corridor. The information would be obtained from specific locations in the corridor known to experience traffic problem caused by weather conditions. The corridor may consist of only a single facility or may be composed of multiple facilities serving similar trips (for example, a freeway and parallel arterials). The information would allow a TMC operator to make tactical decisions about what type of traffic management advisory, control, and treatments to implement in the corridor. Examples of the types of advisory, control, and treatment strategies that could be implemented with this level of deployment include coordinated signal timing plans to promote traffic movement on an emergency or evacuation route, deploying diversion routing around a flooded section of roadway, etc.). Weather information would need to be tightly coupled with traffic information from the corridor. This level of integration would be needed to support automated advisory, control and treatment responses

Complexity- Relative scale (High, Medium or Low) across the levels indicating the degree of difficulty in implementing this level

Medium

Cost - Relative scale (High, Medium or Low) across the levels indicating the cost of implementing this level

Medium

Requirements across the dimensions for strategy

Operational	•TMC to use weather information from sensor network to issue corridor specific weather advisory statements. •TMC system software should make automated suggestions for advisory messages. •TMC system software should make suggestions on corridor specific operational control decisions which would alert and/or reduce impact of weather conditions.
Physical	•Need agency infrastructure capable of sending automated alerts to motorists •Need agency infrastructure capable of operating with other agency infrastructure to affect control decisions (i.e. change of signal timing plans)
Technical	•Need to enhance analysis routines of system data to a more discreet corridor level to monitor and project changing weather conditions that would impact a specific travel corridor. •Need to integrate sensor system data with traffic information to analyze developing condition from the standpoint of affected traffic.
Procedural	•Establish levels for automatic implementation of control system based on sensor and traffic data.
Institutional	•Liaison with other operating agencies / appropriate entities to establish an appropriate basis for sharing alert information and implementing strategic responses.

Item of Integration	Interaction with Meteorologists
Level	1
Title	Focus group or informal gatherings of local professionals from the transportation management and weather communities
Definition	This strategy provides an opportunity for the transportation management and weather professionals to exchange respective professional views. The advantage of this effort is that it promotes familiarization of mutual opportunities in surface transportation weather and fosters a sense of shared values

Complexity- Relative scale (High, Medium or Low) across the levels indicating the degree of difficulty in implementing this level

Low

Cost - Relative scale (High, Medium or Low) across the levels indicating the cost of implementing this level

Low

Requirements across the dimensions for strategy

Operational	•Attend local joint meetings between the weather and transportation communities
Physical	Minimal
Technical	•Email communication between TMC staff and weather staff and advisors
Procedural	•Establish methods to identify reliable and relevant weather community stakeholders of interest to the TMC
Institutional	Minimal
Item of Integration	Interaction with Meteorologists
Level	2
Title	Develop check list of routine weather awareness activities
Definition	In this strategy the focus group or informal gatherings of local professionals in the transportation management and weather communities pursue activities to heighten the awareness of mutual interests, needs, and challenges in surface transportation weather. These activities results in the development of a structured check list of routine weather awareness efforts to address as a shared endeavor.

Complexity- Relative scale (High, Medium or Low) across the levels indicating the degree of difficulty in implementing this level

Low

Cost - Relative scale (High, Medium or Low) across the levels indicating the cost of implementing this level

Low

Requirements across the dimensions for strategy

Operational	•Attend national/regional joint meetings between the weather and transportation communities •Update checklist of routine weather awareness activities •Host local joint meetings between the weather and transportation communities
Physical	•Provide communications interface that provides a remote link between consulting meteorologist and TMC personnel •Provide communications support for in-house weather discussion that provides effective exchanges of information between traffic management activities and meteorological analysis and forecast activities. •Provide communications support for in-house weather discussion that provides
Technical	•Active listserve for exchange of coordination information
Procedural	•Establish guidelines for communications between the weather community and TMC staff •Develop a decision making process that identifies TMC staff who are required to interact with the weather/road weather community.
Institutional	Minimal

12.0 ADDENDUM – POTENTIAL ADVERSE WEATHER MESSAGING SETS

POTENTIAL ADVERSE WEATHER MESSAGING SETS

DMS Message Format (20 Characters)	CMS Message Format (15 Characters)
HIGH WIND ADVISORY	*HIGH WIND ADVISORY*
High Wind Advisory	**Wind Advisory**
MM 66 to 71	**MM 66 to 71**
Use Caution	**Use Caution**
WIND GUSTS REPORTED	*WIND GUSTS REPORTED*
Wind Gusts	**Wind Gusts**
Up to 60 MPH	**Up to 60 MPH**
Reduce Speed	**Reduce Speed**
THUNDERSTORM WATCH	*THUNDERSTORM WATCH*
Thunderstorm Watch	**Thunderstorm**
In Effect	**Watch In Effect**
Until 7:00 PM	**Until 7:00 PM**
THUNDERSTORM WARNING	*THUNDERSTORM WARNING*
Thunderstorm Warning	**Thunderstorm**
Issued At	**Warning Issued**
4:30 PM	**at 4:30 pm**
HAIL	*HAIL*
Hail Reported	**Hail Reported**
Past MM 150	**Past MM 150**
Reduce Speed	**Reduce Speed**
DENSE FOG	*DENSE FOG*
Dense Fog Advisory	**Fog Advisory**
Past MM 175	**Past MM 175**
Reduce Speed	**Reduce Speed**

DMS Message Format (20 Characters)	CMS Message Format (15 Characters)
REDUCED VISIBILITY	*REDUCED VISIBILITY*
Reduced Visibility	**Low Visibility**
Use Headlights	**Use Headlights**
Reduce Speed	**Reduce Speed**
TORNADO WATCH	*TORNADO WATCH*
Tornado Watch	**Tornado Watch**
In Effect	**In Effect**
Until 8:00 PM	**Until 8:00 PM**
TORNADO WARNING	*TORNADO WARNING*
Tornado Warning	**Tornado Warning**
In Effect	**In Effect**
Past MM 140	**Past MM 140**
WEATHER ALERT CANCELLED	*WEATHER ALERT CANCELLED*
Weather Alert	**Weather Alert**
Cancelled	**Cancelled**
At 7:45 PM	**At 7:45 PM**

Integrating Weather Information

Into TMC Operations

Louisiana Traffic

Management Centers

Weather Integration Plan

December 18, 2009

Version: 3.0

Table of Contents

1 Introduction

1.1 Background

In February 2009, Louisiana Department of Transportation and Development (DOTD) Traffic Management Centers (TMC) Operations Staff began researching methods to better integrate weather information into the normal TMC operations. As a result, the TMC Operations Staff identified the Road Weather Management Program (RWMP) as a potential method and contacted the Federal Highway Administration (FHWA) to participate. The RWMP is aimed at reducing the negative impacts of weather on the transportation system by integrating weather information into the daily operations of the state's TMCs. The TMC Operations Staff was subsequently selected to conduct a self-evaluation study and develop a weather integration plan.

The **Integration of Weather Information in Transportation Management Center Operations: Self-Evaluation and Planning Guide** (the Guide) was released by the Federal Highway Administration and consists of a manual and an electronic database tool. This resource presents a self-evaluation guide that *helps a TMC identify the relevant weather events in their jurisdiction, determine the type and magnitude of impacts those events have on their transportation system and on TMC operations and traffic management responsibilities, identify current strategies for managing the impacts of weather, prioritize their identified needs for weather information application and integration, and identify integration strategies and solutions that are best suited to meeting the TMC's high priority needs. The results of the self-evaluation serve as input to support the preparation of a weather information integration plan for TMCs* (the Guide).

Because the weather has such a significant impact on the operations of the state transportation system, integrating weather and operations will simplify the management of any potentially adverse situations. The TMC Operations Staff developed this long-term plan to take a proactive approach to traffic-weather integration and to improve intercommunications among agencies with regards to weather information.

1.2 Purpose and Benefit

Louisiana has established three regional TMCs [Baton Rouge, New Orleans, and Shreveport], a local TMC [Houma], along with a Statewide TMC based in Baton Rouge, which oversees the entire state. FHWA chose Louisiana's TMCs to participate in this study because of the range of weather conditions and TMCs throughout the state. The results of the completed TMC evaluations showed such significant correlation that one set of strategies would best suit the entire state.

Using the strategies outlined in the Guide and presented in this integration plan, the TMCs look to better prepare themselves to handle adverse weather conditions and their impacts on the roadways. This plan identified specific actions the TMC Operations Staff can take to improve the transportation system's operations - both short-term and long-term.

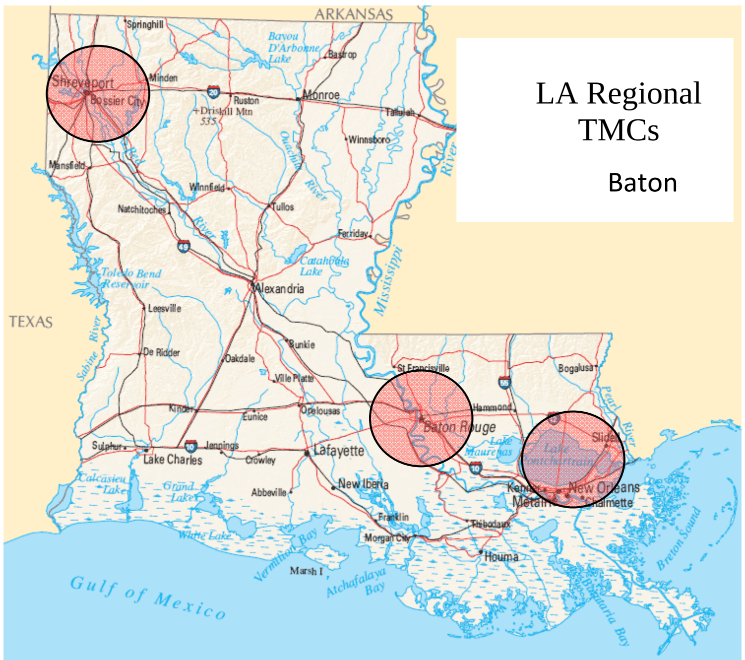
1.3 TMC Operations Overview

The regional and Statewide TMC Operations Staff work closely with one another to monitor and manage the operations of all interstates across the state. The TMCs operate Closed Circuit Television (CCTV) cameras, Dynamic Message Signs (DMS), Vehicle Detection (VD) devices, and the state's 511/CARS traveler information system. The TMC Operations Staff also dispatch the

Motor Assistance Patrol (MAP) vans, send notification emails to key personnel, and use Twitter to alert motorists of hazardous road conditions.

Louisiana experiences a wide variety of weather patterns across the state that impact road safety and operations. Heavy rain events cause flooding of roadways, heavy fog impairs drivers' visibility, tropical weather activity brings strong winds and heavy rain, and icy storms cause slippery roads. By integrating weather information into TMC operations, TMC Operations Staff can inform drivers of the hazardous weather conditions on the roads and aid in the reduction of weather-driven vehicular accidents.

1.3.1 Traffic Management Centers



The Statewide TMC is located in Baton Rouge and oversees all field equipment and operations of the regional TMCs along with field equipment located in areas not covered by the regional TMCs. The Statewide TMC handles all regional based incidents and construction projects. It operates 24/7 and provides after-hour coverage for the regional TMCs.

The Shreveport TMC handles most of the northwest Louisiana area, including Shreveport and Bossier City and the surrounding areas. The interstates located within this area are I-20, I-220, and I-49

The Baton Rouge TMC covers East Baton Rouge Parish and surrounding areas including Denham Springs, Port Allen, and Prairieville. Several major interstates and junctions are located within the Baton Rouge area I-10, I-12 and I-110.

The New Orleans TMC covers the greater New Orleans area, Kenner, Laplace, and the Northshore. I-10 and I-610 are within the New Orleans area, and I-12 runs through Hammond and Covington on the Northshore. The Houma TMC is located in Terrebonne Parish and is supervised by the New Orleans TMC. US 90 runs north of Houma and is covered by the Houma TMC operator.

Any incidents or construction in these areas are handled by the regional TMC. Each TMC can assist in any incident by activating Dynamic Message Signs, notifying key personnel, dispatching MAP and entering the incident into the 511/CARS system. The TMCs work cohesively to assure all incidents, construction and other projects are proficiently handled.

1.4 Weather Integration Self-Evaluation Process

A group of representatives from each TMC gathered to discuss the methods to develop the weather integration plan. It was decided that the most effective approach would be to separately complete the self-evaluation for each regional TMC. The Statewide TMC operations area was split into two sections, Northeast and Southwest, in order to account for the areas not covered by a regional TMC. After completing these separate self-evaluations, each TMC was assessed, and it was determined that one set of strategy outputs could represent the entire state due to the significant similarities in the self-evaluation results of all the TMCs.

Although tropical weather activity, hurricanes, and their effects on the roadways are a major concern in Louisiana, they were not included in the self-evaluation because there currently are substantial plans and policies in place at each TMC to handle these occurrences.

After combining the results from all the TMCs and deciding to have a single weather implementation plan for all the TMCs, it was observed that there is a large gap between the current level of weather integration and the target level. The target level is defined in the Guide as the level to be reached to fully meet the desired weather integration need. It was decided that each TMC would approach the final level in steps; start with small goals and reevaluate using the Louisiana implementation plan until the target level is finally reached.

1.5 Relationship to Other Plan Documents

Previously, weather integration by the TMCs was only approached from a hurricane perspective. Hurricane evacuation plans and other related policies have been in place by DOTD since before the TMCs were established and have continually been reworked throughout the years.

2 TMC Weather Integration Plan

This section explains the TMC Operations Staff's experiences with the Guide and the plan formed from the observations and results of the self-evaluation process.

2.1 Existing Weather and Transportation Management Systems

The existing transportation management systems within the TMCs are currently used by the TMC Operations Staff under the policies of the Standard Operating Procedures (SOPs) written for each center. Operators use CCTV cameras, 511/CARS traveler information system, DMSs, and VDs to monitor conditions and advise motorists in the event of abnormal conditions.

2.1.1 Internal DOTD Weather Resources

The Road Weather Information System (RWIS) deployed by DOTD has been decommissioned due to maintenance and operational issues. Fog sensors were placed in strategic areas experiencing high occurrences of fog. These sensors are no longer active due to many operational issues the state faced. These issues have led DOTD to be cautious about investing anymore money into weather sensing equipment. DOTD is content with primarily using CCTV cameras as secondary fog sensors.

Today the TMC Operations Staff receive weather condition information from local weather broadcasts. Road closures due to flood or ice are received from the State Police. These closures and advisories are entered into 511/CARS and posted on DMS to inform motorists. Weather radios are in place at each TMC to alert operators of severe weather and storm warnings.

2.1.2 External Resources

The TMC Operations Staff at each TMC have access to the Internet and cable TV where weather conditions and forecasts can be monitored daily. Weather events are tracked through the National Weather Service and other sources such as www.weatherunderground.com, www.weather.com, NOAA, the Weather Channel, and television's weather reports.

2.1.3 Decision Support Systems

Each TMC follows a SOP document, which outlines policies for activities and notifications to the public. No policies on weather-related events are in the SOPs; however, the TMC Operations Staff have been following consistent practices. These practices in place at each TMC for weather events will be written into the SOPs.

Currently, flooding, fog, and winter conditions are the only weather-related events that are handled by the TMCs. In the event of flooding, State Police send road closure reports directly to the TMC, and these are entered in the 511/CARS system. These reports are only sent after the road has been closed. There is no forewarning that a road may close from expected large amounts of rainfall. Fog is handled by the TMCs by activating DMS during a fog advisory. Fog advisories are put into place when the local weather station broadcast has stated a fog advisory is in effect. The TMC takes no action in regards to high winds and severe weather, other than monitoring the conditions and lending support if an incident occurs.

2.2 Concepts of Operations

By taking a more proactive approach, receiving information before adverse weather conditions occur, and having set policies and procedures in place, the TMC Operations Staff can better prepare to handle the weather-related traffic impacts and incidents that may occur. The first goal of the TMC Operations Staff is to gather information and data before weather events occur. Through better communications with field operators, construction personnel and DOTD, the TMC Operations Staff hopes to put plans in place to more effectively handle adverse weather events. The TMC Operations Staff envisions receiving weather information in a standard format stating the type of weather event, location (along what stretch of highway), time of the event, and its potential impacts to traffic prior to or as soon as a weather event starts. Potential sources for this information could include MAP, state and local police, weather-based information sites, and other operators monitoring CCTV cameras.

In order to decide what policies and procedures would be most beneficial for the TMCs, potential pilot sites are being proposed in areas on interstates that are most susceptible to adverse weather conditions. The plans and policies for these potential pilot sites are anticipated to be written for proposal over the next year. The locations evaluated for pilot sites include long bridges over large waterways where fog and/or ice are expected.

2.3 Identified High Priority Needs

These items are identified by the TMC Operations Staff as the goals that must be reached first in order to properly integrate weather information into the TMC operations. The needs identified in the table below are from the Guide.

Table 1: Identified High Priority Integration Needs

Louisiana Needs	Definition
Advisory Operations	
LA-1	Improve targeting of weather messages (site-specific; user group specific) to more effectively convey road weather information.
LA-2	Improve message content (for DMS, 511/CARS, Highway Advisory Radio (HAR), websites, etc.)
Institutional Coordination	
LA-3	Develop and implement clear, written policies and procedures for handling weather events.
Gathering and Processing Weather Information	
LA-4	Assistance interpreting weather information and how best to adjust operations in light of that information.
LA-5	Improve the coverage and granularity of weather information in the region with the increased use of weather stations.
LA-6	Better real-time information on road conditions during weather events.

2.3.1 Advisory Operations

The combined high priority needs, LA-1 and LA-2, are intended to assist in increasing motorist information. This includes better informing motorists of weather conditions prior to getting on the road and while on the road. An informed motorist can make better pre-departure decisions, and an already en-route motorist can make better decisions for upcoming driving conditions.

2.3.2 Institutional Coordination

Institutional coordination refers to the need to develop and implement clear, written policies and procedures for handling adverse weather events. Currently the SOPs in place do not include specific sections relating to weather events other than hurricanes. With the help of this weather integration plan, the TMC Operations Staff is going to develop clear and concise strategies on how to best respond and handle weather events and eventually include them in the TMCs' SOPs.

2.3.3 Gathering and Processing Weather Information

The three high priority needs under this section, LA-4, LA-5, and LA-6, all deal with receiving and organizing information that helps to inform the TMC of conditions and consequently enables a more proactive approach. By actively receiving and monitoring weather-related information, the TMC can better prepare in advance for adverse weather conditions. The more usable the data, the better the TMCs can make decisions on the weather events.

Improvements to the policies for receiving and relaying information which are already in place must be made in order to reach the level required by the Guide and selected by the TMCs to reach the TMCs' goals. As data is collected from internet sources, the TMCs' current 511/CARS system, email distribution, DMSs, and advisories will be used to efficiently disseminate information to outside agencies and the public.

2.4 Integration Solutions

The Guide lists 11 Items of Integration and 5 levels of Integration Strategies, as shown in the table below.

Table 2: Integration Strategies

Items of Integration	Strategies				
	Level 1	Level 2	Level 3	Level 4	Level 5
Use of Internal Weather Information Resources	Camera imagery	Radar, satellite, Automated Surface Observing System (ASOS) and Automated Weather Observing System (AWOS) data, and general zone-type forecast information	Level 2 data plus data from Road Weather Information Systems (RWIS) and related networks	Level 3 data plus data from Automatic Vehicle Locations/Mobile Data Computers (AVL/MDC) sources and internal radio communications	Level 4 data with addition of analyzed fields and transformed data parameters (frost index, wind chill, est. snow, ice, water depth)
Use of External Weather Information Sources	General weather information, forecasts, and interpretation provided through media as irregular service (radio and TV weather)	Internet provided, public access general forecasts, weather radar or satellite image or weather-specific broadcast channel	Field observers or probes providing scheduled weather / driving condition information from entire route system	Contractor provided surface transportation weather forecasts targeted at the operational needs of the TMC agencies	Direct connection between private weather information service providers and traffic management software
Availability of Weather Information	Cable channel or subscription weather information vendor providing general weather information	Internet provided weather radar or satellite image on video wall	Field observers or Environmental Sensor Station (ESS) network providing scheduled road or driving condition reports	Vendor provided daily surface transportation weather forecasts and observed weather conditions including Level 3	Meteorologist, located within TMC, forecasting and interpreting weather
Frequency of Weather Forecasts	Receive information of weather forecasts on a request basis	Receive weather forecast once daily.	Receive periodic forecasts several times a day	Receive hourly updates of weather forecasts several times a day	Receive continuous updates of weather forecasts in real-time
Frequency of Weather/Road Weather Observations	Receive information of weather conditions on a request basis	Receive weather observations once hourly	Level 2 plus receive weather/road weather observations when predefined thresholds have been exceeded	Receive weather/road weather observations every ten minutes and when predefined thresholds have been exceeded	Receive weather/road weather observations continuously with data above predefined thresholds highlighted
Weather Information Coordination	Intra-TMC committee tasked with weather information coordination	Identified TMC or maintenance staff member tasked with coordinating weather information at TMC	Dedicated weather operations supervisor	Meteorology staff located within the TMC forecasting and interpreting weather information	Co-location of the Emergency Operations Center/Office of Emergency Management (EOC/OEM)

Items of Integration	Strategies				
	Level 1	Level 2	Level 3	Level 4	Level 5
Extent of Coverage	Sparse Set of Isolated Locations	Network of Scattered Locations	Corridor-level	Multiple-corridor/sub-regional	Regional/Statewide
Interaction with Meteorologists and Climatologists	Focus group or informal gatherings of local professionals from the transportation management and weather communities	Develop check list of routine weather awareness activities	Periodic staff meeting that includes a meteorologist to discuss weather information needs and responses	With a meteorologist present conduct post-event debriefing / regular assessment to fine-tune responses	Daily personal briefings and integrated interruptions by meteorology staff within the TMC
Alert Notification	Monitor media outlets, Internet page, or data stream for critical events	Telephone call list	Manual email/paging system	Automated TMC road weather system-generated notifications (e.g., Email or page from Road Weather Information System or Flood Early Warning System)	Automatic notification through Center-to-Center communications
Decision Support	Ad-hoc implementation of weather management strategies	Use quick-reference flip cards on operator's workstation to implement predefined response	Response scenarios through software supply potential solutions with projected outcomes based on weather / traffic modeling	Automated condition recognition and advisory or control strategy presented to operator for acceptance into ATMS	Automated condition recognition and advisory or control strategy implemented without operator intervention
Weather/Road Weather Data Acquisition	Media Reports	Internet and/or Satellite Data Sources	Across agency intranet and dedicated phone acquisition	Dedicated communications link to state, federal, private data sources	Dedicated communications link to state, federal, private data sources including vehicle-derived weather data

The TMC Operations Staff was able to determine what levels the TMCs are currently operating under and what intermediate levels are needed to be achieved. Based on the needs selected, the target levels of integration were determined by the Guide. Intermediate levels were chosen to provide smaller steps to achieve the target level. Once the selected intermediate steps have been reached, the TMC Operations Staff will reassess how to approach the next level of integration. This process is repeated until the target level is achieved. The following table summarizes the current level of integration, selected intermediate level, and target level defined by the Guide.

Table 3: Current, Intermediate and Target Levels of Weather Integration

Items of Integration	Strategies		
	Current Level	Intermediate Level	Target Level
Use of Internal Weather Information Resources	2	3	4
Use of External Weather Information System	2	3	4
Availability of Weather Information	2	3	4
Frequency of Weather Forecasts	0	2	4
Frequency of Weather/Road Weather Observations	0	2	4
Weather Information Coordination	0	2	4
Extent of Coverage	0	2	5
Interaction with Meteorologists and Climatologists	0	2	3
Alert Notification	1	1	4
Decision Support	1	2	3
Weather/Road Weather Data Acquisition	2	2	4

The following sections contain recommended solutions to meeting the selected and future target levels. All recommendations are subject to DOTD approval and agreement from the other affected agencies indicated.

2.4.1 Use of Internal Weather Information Resources

The current integration level identified by the TMC Operations Staff when the Guide was initially started is Level 2, which includes the use of camera imagery, radar, satellite, and general zone-type forecast information. The target level for the TMCs based on their needs is a Level 4, which includes the use of data from Automated Vehicle Locator/Mobile Data Computer (AVL/MDC) sources and internal radio communications. The integration's intermediate level chosen to be reached by the TMC Operations Staff is Level 3, which includes the use of data from Level 2 plus data from RWIS and related networks.

In order to address the strategies and solutions given by the Guide, RWIS systems could be deployed. Placing RWIS at existing DMS sites and/or other existing powered sites could minimize costs. However, due to past experience with RWIS, DOTD is not willing to provide funding at this time for implementing RWIS systems.

The use of existing RWIS sites is another option for the TMCs. There are RWIS sites that are managed and operated by Louisiana State University (LSU). The information gathered by these sites is public. In most cases, these RWIS sites are not located in relevant positions along the interstates. However, it may be beneficial to utilize the feasible sites and further explore the types of data and collection methods used by this system for its applicability in the future RWIS deployments for the TMCs.

2.4.2 Use of External Weather Information System

Through the use of the Internet, public access general forecasts, weather radar, satellite imagery and the weather-specific broadcast channels, the TMCs currently have a Level 2 integration status in their use of external weather information systems. The self-evaluation Guide suggested the target level for the TMCs, based on the needs requested, should be a Level 4, which includes contractor-provided public access general forecasts, weather radar, satellite imagery or weather-specific broadcast channels. It was decided by the TMC Operations Staff that contractor-provided forecasts were not needed by the TMCs at this time.

The TMCs chose the intermediate Level 3, which includes field observation or probes providing weather/driving condition information from the entire route systems. Louisiana currently interacts through radio correspondence with the MAP operators. MAP vans patrol the interstates in the Baton Rouge, Shreveport, New Orleans, and Lake Charles areas and assist with incident management and lane blockage. Within the weather integration plan, MAP operators would give information on roadway conditions with real-time data and locations of nearby weather events, enabling the TMC Operations Staff to handle these events proactively. In addition to the reports given by MAP operators and the State Police would be asked to send reports of roadway conditions, which would also help ensure the safety of motorists on the roadway. State Police will be contacted once this plan is in place to discuss these potential collaboration efforts.

2.4.3 Availability of Weather Information

As previously mentioned, the TMCs have Internet-provided weather radar and/or satellite images that can be displayed on the video wall or computer monitor(s). If there is a major weather event, it is projected on the video wall within the TMC. This places the TMCs at an integration Level of 2. The goal is to reach level 4, which includes accomplishing all tasks from Level 3 (having field observers or Environmental Sensor Station (ESS) networks providing scheduled road or driving reports). Level 4 requires obtaining daily surface transportation weather forecasts and observed weather conditions from outside agencies or contractors, such as State Police and local weather forecasters, in order to gain more real-time data.

2.4.4 Frequency of Weather Forecasts

Currently there are no weather forecasts being received by the TMCs. Level 2 status is achieved by receiving weather forecasts at least once daily from a reliable weather source as well as from field sources (e.g., MAP operators and/or local police officers). All TMCs will be required to register for their own local weather updates, so they will be informed of any adverse weather in their surrounding area. Also, these reliable weather sources will send email updates on severe weather days, and once daily the TMCs will be updated on all current weather in the area. This is going to be achieved by registering the TMCs for alerts through the local media alert systems. Currently the Statewide TMC receives notification of flooding from the State Police, only after the police have closed the road. The police fill out a form that has been set up to inform the TMC Operations Staff of the location and details of incidents.

2.4.5 Frequency of Weather/Road Weather Observations

The Guide identified the target integration to be Level 4 (receive weather/road weather observations every ten minutes and when predefined thresholds have been exceeded), but the TMC Operations Staff chose Level 2, which is to receive road weather observations hourly. The goal of the TMC is to utilize MAP and State Police and receive weather reports of real-time road data hourly, but only on adverse weather days.

Since MAP patrols many sections of interstate, this is the best way for the TMC to collect real-time data. This would bring the TMC up to Level 2 status of receiving road weather observations hourly. In order to implement this strategy, MAP policy would have to be discussed and rewritten. Also, State Police emails and phone calls could inform the TMC Operations Staff of adverse weather conditions on the roads statewide. By implementing a procedure for MAP and State Police to follow, information can be given to the TMC Operations Staff for taking a more proactive approach to weather. Utilizing people and programs already in place will allow the TMCs to reach their goal of becoming more weather-responsive, while maintaining lower costs at the same time.

CCTV cameras already in place can also be utilized for weather observation. Monitoring weather through CCTV cameras is the fastest way for the operators to confirm weather information in the field. Another source that could be utilized is the local RWIS systems set in place by LSU, as previously discussed in section 2.4.1.

2.4.6 Weather Information Coordination

TMC Supervisors have discussed integrating weather information coordination into daily operations, but there currently is no policy in place at the TMCs. The target level recommended by the Guide to meet the TMCs required needs is a Level 4, which includes having a meteorology staff located within the TMC to forecast and interpret weather information. Because of Level 4's associated cost, the TMC Operations Staff has decided to set a goal of reaching a Level 2. This would require identifying a TMC operator tasked with coordinating weather information for the TMC.

It is recommended that an existing TMC operator at the Statewide TMC be assigned the duties of the weather coordinator. The weather coordinator's responsibilities would include collecting data and distributing the information to the regional TMC supervisors, MAP operators, maintenance staff, and field engineers. The Statewide TMC Operator, weather coordinator, would alleviate the need for a weather coordinator at each individual TMC. Policies will be developed, so each TMC operator will know how to handle weather information received and how to respond to weather events at any time of the day. Policies will also be put in place by the weather coordinator for operations during large scale forecasted weather events.

2.4.7 Extent of Coverage

Currently there are no RWIS sensors in place recording information or being monitored by the TMC Operations Staff. The Guide placed the target integration level of the TMC at a Level 5, which requires expanding the extent of coverage to a network of sensors to provide weather information for the entire state. Due to cost considerations, the TMC Operations Staff is hoping to ultimately reach a Level 4 status, which includes a network of RWIS sensors to provide weather information from multiple corridors and regions. The short-term plan is to reach a Level 2 status, which will expand the extent of coverage to a network of sensors from scattered locations. A long-term plan is needed to establish more widespread deployment of RWIS sensors and to research all the different types of possible weather sensor strategies that may be deployed. The three potential pilot sites being proposed are:

2.4.7.1 Atchafalaya Basin Bridge

The Atchafalaya Basin Bridge is an 18 mile long bridge on I-10, which spans across the Atchafalaya Basin between Baton Rouge and Lafayette. The Basin Bridge is highly vulnerable to heavy fog and rain events.

2.4.7.2 Bonnet Carre Spillway

The Bonnet Carre Spillway Bridge is a 12 mile long bridge on I-10, which runs between Laplace and Kenner to the west of the New Orleans area. The Spillway Bridge is highly vulnerable to heavy fog and rain events.

2.4.7.3 Red River Bridge

The Red River Bridge is located on I-20 between Shreveport and Bossier City. During winter months the bridge is susceptible to ice and freezing rain.

2.4.8 Interaction with Meteorologists and Climatologists

The Guide placed the TMC target level at Level 3, which would require periodic staff meetings along with a meteorologist to discuss weather information needs and responses. The TMC Operations Staff decided to make the goal a Level 2, which calls for the development of a checklist of routine weather awareness activities. Also included in this would be the Level 1 requirements of forming a focus group of local professionals from the transportation management and weather communities, such as local climatologists and meteorologists.

Currently the state climatologist is located at Louisiana State University. Previously there has been no communication among the TMC Operations Staff and the climatologist; however, the TMC Operations Staff wishes to form a relationship with the climatologist in order to receive information regarding flood events and to better choose sites to deploy equipment. Also, some educational training by a meteorologist or climatologist will benefit each operator in understanding weather and its potential hazards.

2.4.9 Alert Notification

The current level of the TMC is Level 1, which includes the monitoring of critical events through media output, along with the use of weather radios, which are currently in place at each TMC. The TMC Operations Staff discussed future plans that would allow them to receive notifications from the weather coordinator and weather sensors in the field, but at this time the TMC Operations Staff would like to remain at a Level 1.

2.4.10 Decision Support

Currently all TMCs have a Level 1 status, but the Guide recommended reaching the Level 3 status, which requires response scenarios supplied through software to identify potential solutions with projected outcomes based on weather and traffic modeling. The TMC Operations Staff decided the first strategy to be implemented would be Level 2’s use of quick reference flip cards on operators’ workstations to implement refined response.

Currently no set manuals or plans are written out for how the TMC Operations Staff responds to weather events. The TMC Operations Staff look to implement a weather manual, within the current SOP, with instructions on how to handle specific weather incidents, along with quick reference flip cards on operators’ workstations to implement predefined responses.

2.4.11 Weather/Road Weather Data Acquisition

Currently the TMCs receive weather and road data through the Internet, television, and weather radar outputs. This puts the TMCs at a Level 2. The Guide recommends reaching Level 4, which requires having a dedicated communications link to state, federal, and private data sources. The TMC Operations Staff have decided to remain at the current level.

2.5 Future Plans

2.5.1 Annual Revisiting of Process

It is recommended that the Guide be revisited each year to verify the TMCs’ progress. Since the TMC Operations Staff chose lower, or intermediate, levels of integration instead of the higher target levels of integration provided by the Guide, revisiting it each year will help to determine new sets of strategies and levels based on the TMCs’ current status. Through this process the TMCs will be able to reach the target levels efficiently, one step at a time.

3 Implementation of Integration Plan

The Guide lists 11 separate integration strategies that help manage different areas of integrating weather into TMC operations. After reviewing all the strategies it was decided that many of these strategies can be implemented by utilizing the same resources; therefore, the TMC Operations Staff decided to combine these strategies and organize them in the order in which they are to occur. With the integration plan completed, weather integration will be implemented at each TMC during the next two years.

3.1 Integration Activities

Several activities will be started by the TMC Operations Staff during the implementation process. Most will begin with a written Memorandum of Understanding (MOU) and changes to policies and procedures. With these changes, the roles of the TMC Operations Staff when responding to weather-related events will change, becoming more proactive in response to road/weather information. Activities that will be started at the TMCs during the initial integration of weather information include writing the policies and procedures to integrate weather and traffic information, coordinating with MAP operators and State Police on weather/road observations and reporting.

3.2 Implementation Sequencing

3.2.1 Implementation Timeframe

There are currently several projects under construction by DOTD that are placing CCTV cameras and DMSs in the New Orleans and Lafayette areas. With the installation of new equipment to inform travelers and to be able to monitor incidents and traffic, the TMC Operations Staff will be better-equipped to handle weather-related events proactively. The first two years of the plan will be devoted to developing plans and policies and acquiring data in order to provide the necessary resources to manage weather events.

3.2.2 6 months

In the next 6 months the TMC Operations Staff plan to identify all weather information sources such as MAP, State Police, and LSU. These sources were discussed in the first through fifth and eighth integration strategies. The flow of information will be discussed, so the information can be received and properly used. The goals and plans of the TMCs will be established, making all participating groups aware of them. Also within this timeframe a weather coordinator will be appointed to write, implement, and direct this plan.

3.2.3 12 months

Concurrent with the first set of goals, in the next 12 months, the TMC Operations Staff plans to develop policies and procedures. These policies and procedures will be developed in order for the flow of information to be utilized properly and efficiently. In these policies and procedures, definitions of advisory thresholds will be defined for statewide consistency. Although agencies and equipment will be different among the TMCs, the standard operating procedures will be the same for each TMC. Also during this time, the pilot sites will be established, and DOTD will develop detailed road device deployment plans for the sites which were discussed earlier, such as the Atchafalaya Bridge, Bonne Carre Bridge, and Red River Bridge.

3.2.4 18 months

Within the next 18 months, the pilot sites will be tested. During this time the weather coordinator will collect data, and the policies and procedures will be followed in order to ensure that the potential pilot sites are operating correctly. These pilot sites will help to determine the usefulness of the equipment and resources.

3.2.5 24 months

Within the next two years, the TMC Operations Staff will update the integration plan in order to identify the next steps in the weather integration process. Since the TMC Operations Staff chose an intermediate level, with the ultimate goal being the target level the Guide originally provided, the Guide will be revisited each year until the TMC Operations Staff and DOTD have made all the desired improvements for weather integration.

The following table lists the integration strategies previously discussed, implementation timeframe, and the sequence in which they should be reached.

Table 4: Integration Strategy Timeframes and Sequencing

Items of Integration	Implementation Timeframe	Implementation Sequencing
Use of Internal Weather Information Resources	1 year	1
Use of External Weather Information System	2 years	2
Availability of Weather Information	2 years	2
Frequency of Weather Forecasts	1 year	1
Frequency of Weather/Road Weather Observations	1 year	1
Weather Information Coordination	2 years	3
Extent of Coverage	5-10 years	4
Interaction with Meteorologists and Climatologists	2 years	1
Alert Notification	2 years	3
Decision Support	2-3 years	3

3.3 Costs Estimates

Table 5 lists the anticipated costs of the integration strategies. Each strategy's initial cost and maintenance cost per year were estimated. The sections following the table explain what these costs include and how they were determined.

Table 5: Estimated Costs for Integration Strategies

Items of Integration	Initial Costs	Maintenance Costs/year
Use of Internal Weather Information Resources	$50,000	$7,500
Use of External Weather Information System	$0	$0
Availability of Weather Information	$2500	$375
Frequency of Weather Forecasts	$1500	$225
Frequency of Weather/Road Weather Observations	$2000	$300
Weather Information Coordination	$6500/year	$0
Extent of Coverage	$250,000	$37,500
Interaction with Meteorologists	$2,000	$0
Alert Notification	$0	$0
Decision Support	$0	$0

3.3.1 Use of Internal Weather Information Resources

Initially, two RWIS stations could possibly be deployed along the first pilot site, Atchafalaya Basin, in order to test weather coordination within the TMCs. This cost estimate of $50,000 includes two RWIS stations, furnished, installed and integrated with the TMC (~$25,000 each). $7500 is required for annual station maintenance and repairs.

3.3.2 Availability of Weather Information

An estimated $2500 is needed to pay for upgrading communications between the TMC Operations Staff and the MAP operators. These upgrades would include access to weather radios, ESS networks, and handheld radios that would allow TMC operators to communicate with MAP operators. Continued annual maintenance of the required communications software is estimated to cost about $375 a year.

3.3.3 Frequency of Weather Forecasts

Subscriptions to private services offering daily weather forecasts and the development of MOUs between the TMCs and any public agencies providing the weather forecasts are estimated to cost $1500. $225 is the projected annual cost of renewing the subscriptions.

3.3.4 Frequency of Weather/Road Weather Observations

The cost estimate for Frequency of Weather/Road Weather Observations is based off the labor cost needed to develop MOUs among the TMC Operations Staff, MAP operators and State Police.

3.3.5 Weather Information Coordination

The estimated cost for Weather Information Coordination is budgeted for a possible salary increase for the weather coordinator. This person would ultimately be responsible for weather integration and weather response statewide, as part of his or her daily TMC operator responsibilities.

3.3.6 Extent of Coverage

Currently there is no DOTD weather reporting in the State. This cost estimate includes system engineering, design, deployment and maintenance of additional pilot sites along the Atchafalaya, Bonnet Carre, and Red River Bridges. These sites would be used to monitor the bridges during weather events. Based on the length of the bridges, up to 10 stations have been estimated for deployment for each pilot site $250,000 is needed to furnish, install and integrate the RWIS sites (~$25,000 each). $37,500 is needed annually to maintain the RWIS stations.

3.3.7 Interaction with Meteorologists and Climatologists

The cost estimate for interaction with meteorologists and climatologists is for costs associated with developing the MOUs that are to be executed for obtaining training from the meteorologists and climatologists. Costs for the training and information received from the meteorologists and climatologists will be discussed and determined at a later date.

3.3.8 Alert Notification and Decision Support

Alert Notification and Decision Support have no associated costs because they will be the responsibility of the weather coordinator. These items will be identified under the policies and procedures.

3.3.9 Initial Costs

Initially there should be no start up costs to implement new policies and procedures into the TMCs. This assumption is based off the idea that most initial work will include changing policies, gathering information, and using free resources. By working with contracts and people already in place at the TMCs there are no expected initial costs. Once equipment is installed, the associated costs will cover deployment of the equipment and maintenance costs such as staffing, support of equipment and training.

3.3.10 Life-Cycle Costs

Currently the total Life-Cycle Costs associated with operating and maintaining the hardware and software components of the system cannot be estimated because the general plan for the first two years does not included specific software and hardware that will be utilized.

3.4 Operations and Maintenance Requirements

3.4.1 Staffing

All new policies and procedures implemented during this plan can and will be handled by the operators currently employed by the TMC.

3.4.2 Support

Maintenance and support will be necessary after the test equipment is installed. It is estimated that the cost of the maintenance and support will be about 10 to 15% of the total cost of the initial estimate per year.

3.4.3 Training

Training for all operators may be required for new RWIS systems and software functions. This cost estimate is minimal and is included under maintenance costs.

3.5 Anticipated Challenges and Constraints

The major anticipated challenge and constraint of weather integration is its cost. Any cost limitations that arise must be resolved before major equipment is deployed.

COLORADO SPRINGS TRAFFIC MANAGEMENT CENTER

WEATHER INTEGRATION PLAN

January 11, 2010

GLOSSARY OF ABBRIVATIONS

ASOS	Automated Surface Observing System
AVL	Automatic Vehicle Location
AWOS	Automated Weather Observing System
CAD	Computer Aided Dispatch
CCTV	Closed-circuit TV
CDOT	Colorado Department of Transportation
CSP	Colorado State Patrol
CSPD	Colorado Springs Police Department
CSTMC	Colorado Springs Traffic Management Center
CTMC	Colorado (statewide) Transportation Management Center
EOC	Emergency Operation Center
ESS	Environmental Sensor Stations
FHWA	Federal Highway Administration
ITS	Intelligent Transportation Systems
MDC	Mobile Data Computer
NOAA	National Oceanic and Atmospheric Administration
RWIS	Road Weather Information System
RWMP	Road Weather Management Program
SWAS	Severe Weather Alert System
TCS	Traffic Control System
TMC	Traffic Management Center
VMS	Variable Message Sign

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1. INTRODUCTION

1.1 Background

The Federal Highway Administration's (FHWA) Road Weather Management Program (RWMP) was introduced to the Colorado Springs Traffic Management Center (CSTMC) in the spring of 2009. The program intent is to help reduce adverse impacts of weather on the transportation system by assisting agencies in integrating weather information into their daily Traffic Management Center (TMC) operation. For this to be an effective goal, the CSTMC had to evaluate its needs for weather integration and develop a plan to implement strategies to meet those needs. CSTMC used the *Integration of Weather Information in Transportation Management Center Operations: Self-Evaluation and Planning Guide* developed by FHWA to identify the relevant weather events in the Pikes Peak region of Colorado and determine the type and magnitude of impacts those events have on the region's transportation system and on the operations and traffic management responsibilities. The tool also helped identify current strategies for managing the impacts of weather, prioritize the identified needs for weather information application and integration, and identify integration strategies and solutions that are best suited to meeting the CSTMC's high priority needs.

1.2 Purpose and Benefit

The CSTMC was selected by the FHWA to assist in the testing and improvement of a working draft of the Integration of *Weather Information in Transportation Management Center Operations: Self-Evaluation and Planning Guide*. The Guide was prepared in Microsoft Access and takes the user through several sections that yield potential weather integration strategies for the TMC. The CSTMC was asked to provide feedback to assist in the improvement of the Guide in addition to developing a weather integration plan.

The Guide was used to develop a set of weather integration strategies for the CSTMC. The CSTMC was selected to participate in the study primarily due to the uniqueness of the center in managing arterial traffic signals throughout the City of Colorado Springs, Colorado.

The CSTMC has mostly been reactive when dealing with both traveler information and traffic signal operations as a result of severe weather that impacts the region. Weather integration should allow the CSTMC to become more proactive with some functions, primarily in traffic signal timing. After working with the Guide and after meeting with the Battelle team, it was decided to focus on identifying weather information requirements for modified signal timing for adverse weather and to further explore strategies for implementing a modified signal timing plan.

1.3 TMC Overview

The CSTMC is very unique compared to the other centers in Colorado. It is a regional facility that covers the Pikes Peak region in El Paso County, Colorado. The center is run and operated by the City of Colorado Springs Traffic Engineering Division instead of by the Colorado Department of Transportation (CDOT). The CSTMC facility houses the Intelligent Transportation System (ITS) equipment and personnel. The ITS equipment includes the signal timing equipment and the computer systems to operate the traffic cameras and Variable Message Signs (VMS). It is also the facility where all CSTMC fiber communications are managed. Some of the factual data for the center and the Pikes Peak region include:

- CSTMC incorporates the management and oversight of nearly 564 traffic signals in Colorado Springs.

- The center is open Monday through Friday from 6:30 am until 6 pm. During those hours the City of Colorado Springs is responsible for managing and controlling all the transportation management devices in the region, including the cameras and variables message signs on the I-25 Corridor. The after-hours control of the VMS reverts to the Colorado Statewide Transportation Management Center (CTMC). The after-hours traffic signal control is managed by the City of Colorado Springs through an emergency callout procedure. While the CSTMC is open from 6:30 am until 6 pm, the traffic signal technicians work between 7:30 am – 5:30 pm.

- The CSTMC has a total of 63 cameras and 47 VMS. There are 29 cameras and 31 VMS on I-25. The other cameras and VMS are on arterial roadways.

- There are 28 miles of coverage on I-25 in the Pikes Peak region with approximately 100,000 annual average daily traffic including 8% truck traffic.

- The population in the region is approximately 400,000.

- There are 1,300 roadway miles in Colorado Springs.

- The elevation in Colorado Springs ranges from 6,000 to around 7,000 feet. The highest elevation location on I-25 is on Monument Hill at approximately 7,300 feet.

- The City's Street Division is responsible for servicing over 7,423 lane miles of roadway, extending over a 196 square mile area. The services performed by the Street Division include pavement repairs and maintenance as well as snowfall removal.

- The average annual snowfall is 42 inches.

The CSTMC collects and distributes traffic information. The most common dissemination methods include VMS, Twitter and media releases. The types of traffic information include:

- Traffic Incidents (crashes, stalls, debris, etc.)
- Road Work

- Major Congestion
- Road/Weather Conditions impacting driving
- Highway/Street Closures for Emergency Calls (fire, police, utilities)
- Power/Traffic Signal Outages
- Fires (controlled burns, structure fires, vehicle fires and wildfires)
- Special Events (parades, graduations, races, USAFA events, World Arena Events, etc.)
- Traffic Campaigns in the State (DUI/Seatbelt)
- Accident Alert Status (Cold Reporting) for the Colorado Springs Police Department (CSPD) and Colorado State Patrol (CSP)
- Chain Law Restrictions for Commercial Vehicles for Monument Hill
- AMBER Alerts

The CSTMC is responsible for traffic signal timing and traffic signal coordination. The computerized Traffic Control System (TCS) allows city staff to continually evaluate and coordinate the City's traffic signals. The City Traffic Engineering staff studies and re-evaluates approximately 30 to 40 arterial streets each year for optimal coordination. The goal of traffic signal coordination is to progress the greatest number of vehicles through the system with the fewest stops and shortest amount of delay.

The Traffic Signal Timing Team is comprised of the City's Traffic Engineer and traffic signal technicians who specialize in the timing and coordination of the traffic signals. The Traffic Signal Timing Team gathers data, evaluates, and studies the major and minor arterial streets. They drive the arterial before and after the new coordination timing is applied to determine the effectiveness and efficiency of the new coordination.

Coordinated signals attempt to provide green lights for the major vehicle flow on a street. This requires that City staff gather data on the volume, speed, distance between signals, and the timing of individual intersections. When the data have been collected a study is done to determine the best timing and coordination of all intersections involved. This may require that the timing of the intersections to be adjusted to facilitate the best flow of vehicles.

When the best coordination has been determined the Traffic Signal Timing Team implements the new timing plan. Studies are conducted to evaluate the efficiency and to make necessary adjustments. Coordination throughout the city is continually monitored and is reevaluated as needed.

Each arterial has special coordination needs and may require that various types of special timing plans be implemented to help the flow of traffic. To accommodate heavy travel demand periods, it may be necessary to have a long cycle length, and this may cause delays on the side streets. Some arterials may have a heavier flow in one direction. This movement may be favored, causing more stops in the less traveled direction. Some intersections may have lagging left turn movements. This means the left turn arrow comes on at the end of the green through light. There may also be planned stops on long arterials to help maintain the flow of vehicles.

Effective coordination greatly improves the flow of vehicles on the arterial by minimizing the interruption of traffic flow and reducing air pollutants. Other than placing a traffic signal in recall when video camera detection is iced over, the effects of weather on traffic flow have not been considered when establishing signal timing plans in the past. This weather integration plan will allow the staff to develop strategies for modifying signal timing plans in response to specific weather events.

A variety of weather in the region provides a significant challenge to motorists, highway maintenance and traffic signal crews. It also creates havoc with TMC equipment including the traffic signals detection cameras and the highway cameras. The weather systems effecting travel include winter snow storms, high winds, thunderstorms, street flooding and fog conditions.

The climate is very unique within the 194 square miles of the Colorado Springs City limits. While there is only a slight change in elevation in various parts of the City, the actual weather and road conditions can be drastically different at the same time in various locations in the City limits. The weather conditions in the spring and summer produce high winds, thunderstorms with flooding and lightning strikes and foggy conditions. The fall and winter produce high winds, snow storms with blowing snow, heavy snow and occasional extreme low temperatures and occasional foggy conditions.

Weather forecasting information is available from a variety of sources. The CSTMC operators have no set schedule to check the various sources of information.

1.4 Weather Integration Self-Evaluation Process

A committee of experts from the region met to conduct their self-evaluation based on the Guide and to seek options to utilize integrated weather information in the traffic management process. The committee was comprised of representatives from the CSTMC, Colorado Springs Traffic Engineering, Colorado Springs Street Department, Office of Emergency Management, and Colorado Department of Transportation maintenance.

Most of these representatives only meet as a group during emergency operations such as blizzards in the winter months. This was an excellent full day (6:30 am until 6 pm), opportunity to allow an exchange of operational procedures during a non-crisis situation. The exchange of information helped operational units better understand each other's weather gathering information and implementation plans based on the weather forecasting information. Both the State of Colorado and City of Colorado Springs highway maintenance have proactive approaches to utilizing the weather information for decision making on plowing streets during winter storms. In the initial meeting it was determined that another source of weather forecasting should be available to assist the TMC with weather information. The Office of Emergency Management receives weather forecast updates daily from Skyview Weather. Skyview Weather is an operational weather company that provides accurate daily forecasts and real time weather information to many clients around the west. These alerts are sent directly to both email and mobile devices. This Skyview Weather report distribution was expanded to include the CSTMC starting in August, 2009. The report is normally received at the CSTMC operator computer by email between 7:30 am and 8 am. While receiving and reviewing the weather forecasts when they arrive, the CSTMC has not initiated any signal timing plans based on winter storm forecasts.

1.5 Relationship to Other Activities and Plan Documents

The CSTMC does not have a regional ITS architecture but instead relies on a CDOT ITS architecture. An architecture is a formalized description of which ITS elements will be deployed, the entities that will deploy them, and how those entities will communicate with the ITS elements and with each other. A Strategic Plan identifies the projects necessary to implement the ITS architecture and determines the relative priorities of those projects. The US Department of Transportation requires that ITS Architectures be developed as a condition for receiving federal funding for ITS projects or for funding of projects that incorporate ITS elements.

The CSTMC does have a plan for incident management response in the Pike Peak region which is a manual and includes detour routes on arterials in the Colorado Springs area. Detours activated under this plan impact signalized timing plans.

2 CSTMC WEATHER INTEGRATION PLAN

Chapter 2 provides the framework for integrating the weather information into the CSTMC operations to improve safety and the ability to keep traffic flowing during inclement weather and road conditions. The first section provides the list of the existing weather and transportation systems in the region. This is followed by concepts of operations for various weather events and their impacts. Then based on the concepts of operations, integration needs and solutions are identified.

2.1 Inventory Existing Weather and Transportation Systems

There is currently a variety of weather related systems in use or available at the CSTMC to provide useful traveler information to the motorist, media and general public.

2.1.1 Weather Gathering Sources

The weather and road conditions information are gathered at the CSTMC from multiple sources including:

- Highway Traffic Cameras - the TMC operators at the CSTMC utilize the streaming cameras to help determine the weather and road conditions. These cameras have pan-tilt-zoom features that allow the operator to direct the camera view on specific problem areas. Operators can use these cameras to obtain visual confirmation of current weather conditions at specific locations in the region. There are 29 cameras located on or along the I-25 corridor. There are another 34 cameras located along arterial roadways in the region.

- Intersection Video Detection Cameras – the signalized intersections have camera detection. These cameras are generally mounted on the mast arm overhanging an approach and are used by the traffic signal controller to determine vehicle presence on each intersection approach.

- CTMC website http://www.cotrip.org/home.htm - the website includes statewide road and weather conditions. The same information can also be accessed by utilizing the 511 phone number system or the (303) 639-1111 phone number for the CDOT road information hotline.

- Computer Aided Dispatch (CAD) - citizens making 911 calls or non-emergency calls for police that are weather related appear in the CAD calls that can be reviewed by the operators at the CSTMC. These types of traffic hazard calls are normally related to fog or snow conditions that impact the traffic signal detection. Other types of hazards called in might include actual road conditions, such as deep water standing on the roadway, icy conditions where vehicles cannot maneuver on a grade, etc.

- Law enforcement - both Colorado State Patrol and City of Colorado Springs Police Department officers report conditions which are broadcast over the police radios which are monitored by the TMC operators.

- National Oceanic and Atmospheric Administration (NOAA) - the CSTMC has internet access to check weather on the internet at the NOAA website.

- Severe Weather Alert System (SWAS) – the free service for Twitter users provides severe weather alerts plus hourly condition reports for the Colorado Springs area. The information is generated from NOAA. This system was implemented at the CSTMC following the initial weather integration meeting when the resource was identified and once a Twitter account was established at the CSTMC.

- Skyview Weather - the CSTMC receives email weather updates daily, normally between 7 am and 8 am. In more severe weather conditions there are more frequent updates during the day as weather conditions change. The weather reports are from a meteorologist at Skyview Weather and during a winter storm they provide information on estimated snow accumulation by periods of time over the next 24 hours, temperature ranges, wind speed, wind chill, relative humidity, etc. This is a service subscribed to by the City of Colorado Springs, the CSTMC, the Colorado Springs Office of Emergency Management and the City of Colorado Springs Street Department, all of which are on the distribution list. In August 2009, the CSTMC was added to the distribution list (at no cost) and currently receives the same email forecast. This system was implemented at the CSTMC following the initial weather integration meeting.

- CDOT maintenance supervisor - the maintenance supervisor for CDOT Region 2 in the Pikes Peak region calls in with severe weather conditions impacting travel on the state roadways such as I-25, Hwy 24, Hwy 94 and Powers Blvd.

Figure 1-1 Regional Map of Colorado Springs

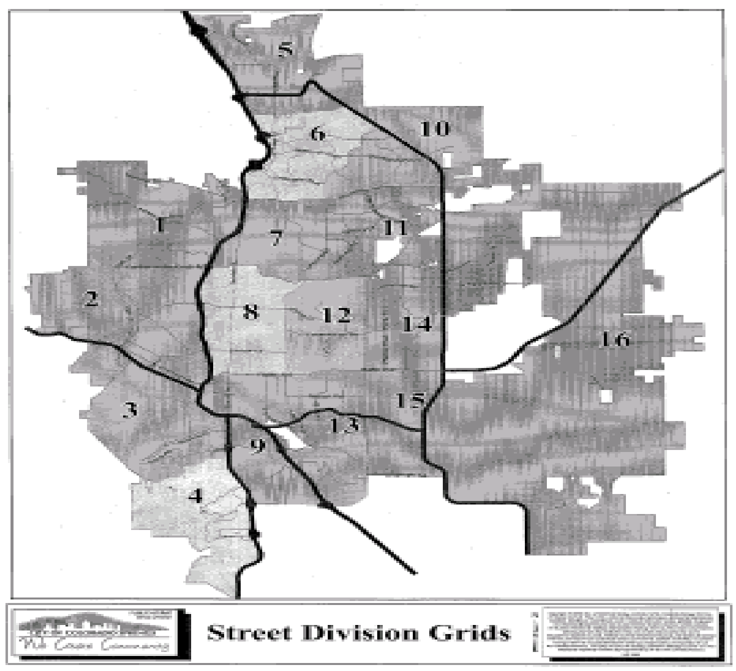
- Local media weather information on the internet - weather information is gathered from the internet either through searching the individual websites or the twitter releases immediately received by the operator on duty. Some of the twitter weather updates are posted on NewsFirstWeb, kktv11news, NEWSCHANNEL_13, NewsFirstToday and KXRM. These are severe weather information sources from local Colorado Springs meteorologists. The websites that are also normally searched include Weather Underground, weatherforyou.com and NOAA.

- Digital Weather/Hazard Alert Monitor - the system displays an audible alert and automatically broadcasts National Weather Service (NWS) alerts. This device is located next to the TMC operator console station.

- CDOT Weather Stations - CDOT operates two weather stations located along the I-25 corridor, one at MM 146 near Garden of the Gods Road and the other at MM 163 near Monument Hill. The weather station data include temperature, precipitation, dew point, humidity, wind (mph/dir), gust (mph/dir) and visibility (miles). This information is updated every 30 minutes and is available on the COTRIP.ORG website.

- The City of Colorado Springs Street Department utilizes 16 grids for snow removal. They determine road conditions from spotters as well as Road Weather Information Systems (RWIS) for those grids to determine the priority of snow removal for Colorado Springs.

Figure 1-2 Colorado Springs Street Division Grid Map



- RWIS on the Colorado Springs Scan Web System consists of seven remote weather stations that act as an early warning system during storm conditions. The stations are strategically located throughout the city. The system provides comprehensive information about air temperatures and wind speed, pavement temperatures, sub-pavement temperatures, chemical concentration and the freeze point of roadways, which effects not only icing potential but also the type of treatment the Street Division applies on hills and at intersections. The information refreshes every 15 minutes and is available to City employees on the web. The weather station locations are:
  - 21st Street at Skyview
  - Centennial Boulevard at Allegheny South
  - Highway 24 at Marksheffel
  - Jamboree at Chapel Hills
  - Pikes Peak Avenue at Union Boulevard
  - Star Ranch Road at Highway 115
  - Platte Ave. at Powers Blvd

2.1.2 CDOT Signals

The CSTMC handles the signal timing and maintenance for the signals in the Colorado Springs area. This includes CDOT signals that are part of the on- and off-ramps from I-25. The CDOT signals were contracted over to the City of Colorado Springs for both maintenance and timing related issues.

2.1.3 Signal Systems and Control

The traffic signals in Colorado Springs are connected and controlled from within the CSTMC facility, providing the radio communication link is operational. This allows timing plans to be managed remotely from within the control center without a technician having to respond to the control cabinet at each intersection -. There are traffic cameras with video feeds back to the CSTMC and 120 signalized intersections that can be observed from the existing TMC cameras. However, the cameras have limited capabilities in adverse weather conditions due to limited visibility distances in fog and blowing snow and from the ice and moisture that adheres to the camera exterior protective globe.

2.1.4 Traffic Management Centers

The CSTMC is one of four centers in Colorado. There are three CDOT operated facilities which include the Colorado Traffic Management Center in Golden, Colorado, the I-70 Hanging Lake Tunnel Center and the I-70 Eisenhower Memorial Tunnel Center. All three facilities are 24-7 operations. Both the Hanging Lake and Eisenhower Tunnel centers serve as regional facilities for their particular area of responsibility in Colorado, mainly in and around the tunnels along Interstate 70. The CTMC located in Golden is a statewide center for collecting and distributing traffic information. The CTMC takes over VMS control after-hours but does not take over signal timing plans or maintenance issues after-hours.

The CSTMC maintains staffing after-hours under very limited circumstances. One possible situation involves a major incident on I-25 with either a total blockage in one or both directions or partial lane blockages estimated to last over 2 hours. The other situation would be following an activation of the Emergency Operation Center (EOC) by the Colorado Springs Office of Emergency Management for adverse weather conditions with a likelihood of highway closures in the region. Under these circumstances one operator may stay after-hours at the TMC. The operator activities could include activation of VMS, coordination with CDOT on State road closures, coordination with the EOC on other arterial street closures, and provision of updates to the media on highway closures or incidents.

The weather related VMS messages are designed to warn motorists of road and weather conditions downstream. The message content is usually intended to inform of closures or limited visibility or hazardous conditions that hopefully results in drivers reducing speeds for the conditions or totally changing travel plans to include staying off the highway. If adverse weather conditions occur after normal CSTMC hours, the CTMC in Golden will normally place up advisory messages on the VMS.

The CSTMC has a limited staff and no availability to call in additional staff without the consequence of an overtime commitment which is not feasible due to the budgetary restrictions. One traffic signal technician is on call and can respond on overtime for emergency situations when traffic signals are inoperative. Following a weather related incident the changing of VMS is either conducted by the CTMC or the CSTMC during normal operational hours. Non-emergent traffic signals issues are resolved when the traffic signal technicians return to work on their normal work schedule.

2.2 Concept of Operation

This section provides two scenarios to demonstrate how the CSTMC envisions weather information being integrated into transportation operations. Weather integration is most critical when a severe weather incident occurs which will likely have a major impact for the traveling public and the roadway system.

The following two events provide examples of the vision of our concept of operation after an analysis of the CSTMC is complete. The selected roadway segment focused upon during the winter storm event is representative of many other arterials in the Colorado Springs area.

2.2.1 Fog Event

On a Tuesday morning in early May a fog system moves down the front range of the Pikes Peak region. The visibility on Monument Hill is approximately 500 feet. The sight distance is estimated by a CSP trooper who works in the area. The traffic cameras can just barely see the highway. The intersections in the Colorado Springs area are clear with unlimited visibility.

The CSTMC operator receives the morning email from Skyview Weather indicating the northern portion of Colorado Springs and El Paso County can expect heavy fog rolling in after 8 am and clearing by later morning. Other weathers sources received as tweets at the CSTMC also confirm the high likelihood of foggy conditions.

Fog causes two major problems for travel in the region. One problem is with highway travel with motorists traveling at an unsafe speed that fails to allow for sufficient stopping time for an incident that may occur in front of a motorist. It is difficult for the CSTMC to properly identify and verify an incident under foggy conditions and post the information on the VMS due to the limited visibility from the cameras. Fog warnings on VMS need to be placed upstream of the fog to warn driver prior the condition. When there is an incident blocking a traffic lane in a foggy location any VMS close to the incident also in the foggy environment may not be readable with limited visibility from the fog. The other problem is traffic signal video detection under foggy conditions. This may result in some directions of travel not getting any or sufficient green time at an intersection.

The CSTMC operator monitors the highway traffic cameras and places a message on a VMS sign to warn motorists northbound on the Interstate to expect heavy fog and limited visibility ahead. As the fog moves to the south it is pretty obvious that it will approach the northern end of Colorado Springs around 8 a.m. The operator notifies the signal technician for the north end of the city of the approaching fog conditions. The signal technician goes into the system and places his intersections into recall for 3 hours. The recall setting allows all directions of traffic including turning movements to get a set amount of green time without utilization of detection equipment to determine if vehicles are in queue at an intersection. The detection mode for fog on the video detection system is less than adequate and the reason for the manual recall.

At approximately 8:30 am the CSTMC operator observes from the intersection cameras that the fog has lifted and notifies the signal technician. The signals are then placed back into their normal timing plan. The VMS message for the limited visibility is turned off.

A fog event is infrequent in the Colorado Springs area and normally is isolated to a particular section of Colorado Springs and not the entire City. It normally occurs in the morning hours during the morning commute and moves through a particular highway corridor and may last from 15 minutes up to two hours.

The anticipated impacts include:

- The intersection cameras are unable to determine the traffic volume and backups.
- The video detection cameras are unable to detect vehicles approaching the intersection and fail to provide a call for a particular direction of travel causing certain directions of travel to not receive green time, resulting in traffic backup and citizen complaints.
- Traffic is moving at slower speeds with increased following distance which would impact timing plans.

With short term duration of the fog conditions the necessary fix would be to get all the effected signalized intersections into recall to make sure all phases receive adequate green time to facilitate the movement of traffic at the intersections. When the conditions clear, the prior timing plans need to be reinstated.

The one unresolved dilemma revolves around a fog event that occurs after-hours. Without on-duty operators the visual inspection of conditions is not possible. While the CTMC in Golden does receive live video feeds of the CSTMC cameras they have limited staff after-hours and only play a reactive role for something like fog that occurs in the Pikes Peak region. They do not monitor cameras feeds for activity but do put up VMS if contacted by CSP or CDOT. While 90% or more of the fog conditions are on the Monument Hill area, only a small percentage of them move south and have an impact on the traffic signals in the Colorado Springs area. For that reason in would not be feasible for the CSTMC to contact the on-call signal technician based on the possibility of fog moving into the area. The overtime budget is already stretched and this additional expenditure could not be justified.

2.2.2 Winter Snow Storm Event

During the last week in October on a Monday, there is a weather forecast for a severe snowstorm to move into the region by 6 pm. All day long on Monday the CSTMC operator is receiving weather updates from all the available weather sources. The Colorado Springs Emergency Operation Center is activated based on the storm prediction of 12 inches of snow for the region.

At 4 pm the weather service predicts the snow to start falling by 5 pm during rush hour. The decision is made to place the signals in recall for the evening until the morning when the signal technicians return and can evaluate the conditions.

On Tuesday morning the weather service indicates the snow storm is moving out of the area after dropping 10-15 inches of snow in various locations in Colorado Springs. Temperatures are to remain below freezing for the week with limited sun to melt the snow. The CSTMC believes, based on the weather and road conditions, that the modified traffic signal plan should be activated for the week until the roadway is cleared and traffic flow returns to normal. While plowing did occur, the roadways are still icy packed and traffic continues to travel at speeds well below the posted speed limits. Motorist at intersections still cannot see and stop in the designated traffic lanes where video detection cameras can detect waiting traffic for through or turning movement, and therefore it is necessary to keep the signals in recall.

A winter snow storm event is unpredictable and could occur anytime between October and April in the Colorado Springs area. There is usually some advanced warning for a snow storm. The storm may impact the entire City for just an hour or two or a few days. A majority of storms that occur overnight or in the morning hours can expect to be mostly cleared out and with traffic returning back to normal by the noon hour.

The anticipated impacts include:

- The intersection cameras are unable to determine the traffic volume and backups.
- The video detection cameras are unable to detect vehicles approaching the intersection and fail to provide a call for a particular direction of travel causing certain directions of travel to not receive green time, resulting in traffic backup and citizen complaints.
- Traffic is moving at slower speeds, increased following distance, have increased stopping distance and slower acceleration at start up.
- With snow covered roadways drivers do not always have proper vehicle placement to reach the zone for the video detection cameras.
- The city has 15-20 intersections with grades or other characteristics that are impacted by slick roadways. It is necessary to place these signals in recall because motorist

may not able to see the lane markers in order to place their vehicles at the intersections where video detection can properly work. Additionally the increased safe following distance on the grade would be significant enough that the detection would not recognize addition vehicles approaching and immediately revert to a red condition. Recall would provide the necessary green signal time to allow traffic to proceed through the intersection where the normal timing plan would likely not provide for the necessary movement of traffic.

The first priority for the CSTMC during the storm event is to get the signal time plans into recall to provide green time for all phases at the intersection. The next is to look at a modified signal timing plan to accommodate an extended period of time with adverse road conditions. Finally when the conditions clear, the timing plans need to be reversed and the prior timing plan reinstated.

The same unresolved dilemma as in the fog event revolves around an event like this that occurs after-hours or returns to normal conditions after-hours. The CSTMC needs to determine a best practice for these situations.

The CSTMC needs to collect certain weather and roadway data that will necessitate the modification of signal timing plans. With fog and blowing snow it will be the visibility distance that will start to impact the detection capabilities at the intersections. With falling snow it will be the accumulation level that will start to impact travel speeds.

2.3 Integration Needs

The Self-Evaluation Guide assisted the CSTMC in identifying their most important operational needs. The Traffic Control Operations received the highest rating based on the inputs. The Advisory Operations, Institutional Coordination and Weather Information Processing and Gathering received a medium priority (see Table 2-1).

Table 2-1 CSTMC Operational Needs and Priorities

Traffic Control Operations	**Priority**
Improve safety at intersections during weather events	High
Improve traffic signal timing during weather events to facilitate traffic movement	High
Advisory Operations	**Priority**
Provide better pre-trip weather condition information to aid travelers in their decision-making	Medium
Improve message content (DMS, 511, HAR, Web sites, etc.)	Medium
Institutional Coordination	**Priority**
Improve coordination with local public safety and emergency agencies	Medium
More coordinated responses and information with adjacent jurisdictions/regions	Medium
Weather Information Processing and Gathering	**Priority**
Assistance in interpreting weather information and how best to adjust operations in light of that information	Medium
Better real-time information on road conditions during weather events	Medium
Better prediction of impact of weather events including assessment of reduction in capacity	Medium

2.3.1 Traffic Control Operations

The Traffic Control Operations includes the improvement of safety at intersections during weather events and the improvement of traffic signal timing during weather events to facilitate traffic movement. The winter weather in the Colorado Springs area can range from similar conditions throughout the city to delayed impact at various times throughout the city with some portions of the city having no adverse conditions at all. It is necessary to have weather and road conditions accurately updated throughout various parts of the city.

Winter driving is the most problematic, resulting in an increased crash rate at intersections. It is difficult to determine the actual percentage increase of the crash rate since the City of Colorado Springs frequently goes on Accident Alert status during the adverse winter driving conditions and the non-injury crashes do not get reported and counted. Under Accident Alert status a motorist does not get a police response to investigate the crash providing there are no injuries and no drugs or alcohol are involved. The motorists exchange information and complete their own traffic accident reports at a later date and time. This Accident Alert status is activated when there are more crashes occurring then can be investigated by law enforcement personnel. The increased crash rate has to do with many factors. One is the grades at intersections making it difficult to stop on icy roads when approaching the intersection or to start accelerating after stopping. Another is the normal stopping distance and ability to stop when the light cycles from green to amber to red.

The CSTMC management believes that traffic operations on arterial roadways can be improved in inclement conditions by utilizing weather-related signal timing plans that will accommodate changes in driver behavior and a disruption of video camera detection equipment. It should also help improve safety at intersections. The CSTMC needs to verify the standard practice of extended amber and red times during traffic signal timing modification in adverse road conditions.

Weather has an effect on traffic flow along signalized arterial roadways. This is primarily due to a reduction in visibility, a reduction in pavement friction and an impact on driving behavior and vehicle performance such as maneuverability and traction.

During inclement weather, primarily snow and ice, drivers increase following distance, reduce speed and utilize a slower acceleration rate. Weather can also increase both crash frequency and severity. Since timing plans are designed for normal driving conditions, the timing plans may not be as favorable when traveling on roadways in inclement weather and road conditions.

Inclement weather and pavement conditions generate reductions in traffic volumes and speeds, and increased delay and congestion. This weather-related delay can be alleviated by implementing modified signal timing plans that account for slower travel speeds and lower traffic flow rates or volumes.

Weather, primarily fog and snow, impact the video detection of vehicles at intersections. Vehicles cannot be properly detected due to the weather conditions and road conditions. Weather such as fog or blowing snow can obstruct the video detection. Snow or ice covered roadway markings can result in drivers stopping in locations at an intersection which are out of the video detection camera zone and therefore result in no detection of vehicles.

Table 2-2 Weather Impacts on Colorado Springs Roadways and Traffic Operations

Weather Event	**Impact to Roadway**	**Impact to Traffic Operations**
Rain Snow Hail Flooding	Visibility reduced Lane obstruction Pavement friction reduced Vehicle performance reduced Damage to infrastructure	Roadway capacity reduced Speeds reduced Delays increased Crash risk/rate increased Roadway closures
High Winds	Visibility reduced due to blowing snow Lane obstruction due to drifting snow and blown debris Vehicle performance reduced	Speeds reduced Delays increased Roadway closures Damage to traffic signals
Fog	Visibility reduced detection systems	Roadway capacity reduced Speeds reduced Delays increased Crash risk/rate increased Traffic control device detection failure
Lightning	Damage to infrastructure	Traffic control device detection failure Communication services lost from power outage

There are two approaches for the CSTMC to improve signal timing plans. One is to place signal plans into recall when the camera detection is obscured by weather conditions. This will guarantee every phase of the signal is operational for every direction of travel even when no vehicles are detected by the video detection system. The other is to modify signal timing to accommodate changes in driving behavior based on driving conditions.

This will require gathering statistical data during inclement weather and evaluating the impact to the roadway during the event. Currently it is fog, freezing rain, blowing snow and snow covered intersections that mostly impact traffic signal timing plans. Detection issues due to the weather and road conditions require manually placing the traffic signals into recall to provide assurance that all directions of travel at the signal get a green signal during the cycle. The CSTMC needs to establish the predefined threshold for conditions to activate a modified signal timing plan.

2.3.2 Advisory Operations

The advisory operations include providing better pre-trip weather conditions information to aid travelers in their decision-making and the improvement of message content on VMS, 511, web sites, etc.

The CTMC in Golden, Colorado handles the updates to the 511 Colorado highway advisory systems. The CSTMC can work on improving message content on VMS for the conditions downstream on the highway by either listing the conditions on the VMS or encouraging drivers to utilize the 511 system to check on conditions. Many of the VMS in the region are two-line signs which limits the message content that can be effectively displayed. The use of Twitter in the CSTMC started in the summer of 2009. The tweets generated on road and weather conditions, accident alert status, and crashes in the region are an excellent method of using new technology to provide motorists information that may aid in decision making before heading out on the roadway. Nearly all the local media in the region follows the CSTMC tweets on traffic crashes and road conditions. The CSTMC needs to work on marketing the information available to the public so more citizens are aware of the travel information available listed on the CSTMC twitter account or the City of Colorado Springs web site.

2.3.3 Institutional Coordination

The institutional coordination includes improved coordination with local public safety and emergency agencies and more coordinated responses and information with adjacent jurisdictions/regions.

The CSTMC primary coordination is with the Colorado Springs Police Department, the Colorado State Patrol, CDOT and the CTMC. The CSTMC shall continue to work on enhancing the coordination effort with these agencies.

2.3.4 Weather Information Process and Gathering

The weather information process and gathering includes assistance in interpreting weather information and how best to adjust operations in light of that information, better real-time information on road conditions during weather events and better prediction of impact of weather events including assessment of reduction in capacity.

The CSTMC personnel need to obtain training on interpreting and utilizing weather station information. Combining the weather station information with additional weather forecast information will allow the CSTMC to make proactive operational decisions in a timelier manner. This information can be distributed to the traffic signal technicians as well as the general public with the VMS and the CSTMC account.

2.4 Integration Solutions

The CSTMC analyzed each integration strategy based on the current integration level and the Guide recommended integration level. The CSTMC personnel then determined a chosen weather integration level based on what was thought to be most feasible for the CSTMC. The integration strategies are listed in Table 2-3 below. The levels of integration are described in Table 2-4.

Table 2-3 Current, Recommended and Selected Weather Integration Strategies

Integration Item	Current Integration Level	Guide Recommended Integration Level	Chosen Weather Integration Level
Use of Internal Weather Information Resources	1	4	3
Use of External Weather Information Resources	2	4	3
Availability of Weather Information	2	4	4
Frequency of Weather Forecasts	1	4	3
Frequency of Weather/Road Weather Observation	1	4	3
Weather Information Coordination	None	4	2
Extent of Coverage	4	5	4
Interaction with Meteorologists	None	3	2
Alert Notification	1	4	3
Decision Support	1	3	2 & 3
Weather/Road Weather Data Acquisition	2	4	3

The levels of integration are described in Table 2-4 below to provide an understanding of what the strategy is that the CSTMC has chosen.

Table 2-4 Levels of Integration

Item of Integration (Broad Requirement/ Concept)	Levels of Integration					
	None	**Level 1**	**Level 2**	**Level 3**	**Level 4**	**Level 5**
Use of Internal Weather Information Resources	None	Camera imagery	Radar, satellite, ASOS and AWOS data, and general zone-type forecast information	Level 2 data plus data from Road Weather Information Systems (RWIS) and related networks	Level 3 data plus data from Automatic Vehicle Locations/Mobile Data Computers (AVL/MDC) sources and internal radio communications	Level 4 data with addition of analyzed fields and transformed data parameters (frost index, wind chill, est. snow, ice, water depth)
Use of External Weather Information Sources	None	General weather information, forecasts, and interpretation provided through media as irregular service (radio and TV weather)	Internet provided, public access general forecasts, weather radar or satellite image or weather-specific broadcast channel	Field observers or probes providing scheduled weather / driving condition information from entire route system	Contractor provided surface transportation weather forecasts targeted at the operational needs of the TMC agencies	Direct connection between private weather information service providers and traffic management software
Availability of Weather Information	None	Cable channel or subscription weather information vendor providing general weather information	Internet provided weather radar or satellite image on video wall	Field observers or ESS network providing scheduled road or driving condition reports	Vendor provided daily surface transportation weather forecasts and observed weather conditions including Level 3	Meteorologist, located within TMC, forecasting and interpreting weather
Frequency of Weather Forecasts	None	Receive information of weather forecasts on a request basis	Receive weather forecast once daily.	Receive periodic forecasts several times a day	Receive hourly updates of weather forecasts several times a day	Receive continuous updates of weather forecasts in real-time
Frequency of Weather/Road Weather Observations	None	Receive information of weather conditions on a request basis	Receive weather observations once hourly	Level 2 plus receive weather/road weather observations when predefined thresholds have been exceeded	Receive weather/road weather observations every ten minutes and when predefined thresholds have been exceeded	Receive weather/road weather observations continuously with data above predefined thresholds highlighted
Weather Information Coordination	None	Intra-TMC committee tasked with weather information coordination	Identified TMC or maintenance staff member tasked with coordinating weather information at TMC	Dedicated weather operations supervisor	Meteorology staff located within the TMC forecasting and interpreting weather information	Co-location of the EOC/OEM

Table 2-4 Items of Integration (continued)

Item of Integration (Broad Requirement/ Concept)	Levels of Integration					
	None	**Level 1**	**Level 2**	**Level 3**	**Level 4**	**Level 5**
Extent of Coverage	None	Sparse Set of Isolated Locations	Network of Scattered Locations	Corridor-level	Multiple-corridor/sub-regional	Regional/State wide
Interaction with Meteorologists	None	Focus group or informal gatherings of local professionals from the transportation management and weather communities	Develop check list of routine weather awareness activities	Periodic staff meeting that includes a meteorologist to discuss weather information needs and responses	With a meteorologist present conduct post-event debriefing / regular assessment to fine-tune responses	Daily personal briefings and integrated interruptions by meteorology staff within the TMC
Alert Notification	None	Monitor media outlets, Internet page, or data stream for critical events	Telephone call list	Manual email/paging system	Automated TMC road weather system-generated notifications (e.g., Email or page from Road Weather Information System or Flood Early Warning System)	Automatic notification through Center-to-Center communication s
Decision Support	None	Ad-hoc implementation of weather management strategies	Use quick-reference flip cards on operator's workstation to implement predefined response	Response scenarios through software supply potential solutions with projected outcomes based on weather / traffic modeling	Automated condition recognition and advisory or control strategy presented to operator for acceptance into ATMS	Automated condition recognition and advisory or control strategy implemented without operator intervention
Weather/Road Weather Data Acquisition	None	Media Reports	Internet and/or Satellite Data Sources	Across agency intranet and dedicated phone acquisition	Dedicated communications link to state, federal, private data sources	Dedicated communication s link to state, federal, private data sources including vehicle-derived weather data

The CSTMC determined the variety of impacts and requirements on various aspects of TMC operations, procedures, and capabilities in the five dimensions of integration along with the necessary steps in order to successfully achieve a specific level of integration that will meet the CSTMC needs. The five dimensions of integration described in the Guide are described in Table 2-5.

Table 2-5 Five Dimensions of Integration

Operational Integration. The ways in which data and information are shared and used by TMCs and connected agencies, organizations, and systems to support traffic operations. Integrated control of traffic systems, and shared decision-making with regard to TMC traffic functions. The remaining four dimensions support operational integration.
Physical Integration. The agencies, organizations, and systems physically linked or collocated for the purpose of sharing data or information in support of traffic operations.
Technical Integration. The data and information communicated, exchanged, and shared through physical linkages among people, systems and organizations, both within a TMC and between a TMC and other entities. This data and information exchange can be achieved through a range of means from verbal exchanges to automated electronic exchanges and decision support systems that integrate available information to enhance operational efficiency and effectiveness
.**Procedural Integration.** The development and use of policies, plans and procedures that support an integrated traffic operations in a TMC; the extent to which policies, plans and procedures are written down, made accessible to staff, reflect multi-agency interests and responsibilities, and are tested and reinforced with training and exercises; and, the coordination of policies, plans and procedures across integrated agencies and organizations.
Institutional Integration. The level of commitment and partnership within and between participating organizations and agencies to achieve successful integration; leadership supporting the value of integration, and the willingness of partners to seek to collaborate to solve problems jointly; the clarity with which participant organizations' roles and responsibilities in support of integrated operations are spelled out and understood; the vertical and horizontal collaboration within and between agencies and organizations in support of TMC traffic operations; and, agreements established among entities to support interaction and integration.

In this section each of the integration strategies is listed with a summary of the CSTMC action steps to achieve the level selected and the possible cost of implementation for the chosen level.

2.4.1 Use of Internal Weather Information Resources

This item pertains to the use of weather data and information resources that are available to the CSTMC and to the personnel assigned. The use of internal weather information resources for level 3 utilizes radar, satellite, ASOS and AWOS data, and general zone-type forecast information. This level of integration will provide the CSTMC with data on a local and regional scale. Radar and satellite will provide past and present data on possible precipitation over a designated region while ASOS and AWOS will provide observations of conditions at precise, pre-determined locations. General zone-type forecast information will give the TMC a broad picture of possible weather events that may affect the region. These types of forecasts will provide information on a regional scale, including expected maximum and minimum temperatures, average wind speed and direction, cloud cover, chance of precipitation within the region and range of timing associated with precipitation. The TMC must also incorporate data from RWIS Environmental Sensor Stations (ESS) and other weather networks that may be available for a given location. ESS will provide the TMC with weather directly adjacent to the road allowing for better understanding of weather conditions affecting the road surface and traffic flow. The ESS observations may include, but are typically limited to air temperature, relative humidity/dew point temperature, wind speed and direction, pavement surface temperature, pavement surface condition and chemical concentration or freeze point temperature and visibility.

Based on the steps listed in the five integration dimensions for levels 1-3, the CSTMC will need to identify the staff member(s) to be trained on RWIS data. The RWIS data are already available at the TMC. This will be one of the TMC operator positions. The actual processing of the RWIS information will need to be established and documented into a procedure. Most of the necessary equipment is in place to proceed so there are no initial projected costs to implement. Prior to the start of utilizing the Self-Evaluation and Planning Guide, the CSTMC would only check weather forecasts occasionally, primarily on the internet. In the past 6 months the CSTMC has greatly increase the amount and type of weather data that are received at the center. These additional steps to improve the data flow from the various sources have elevated the CSTMC to a level three. It would be possible to reach level four using data from Automatic Vehicle Location (AVL) and Mobile Data Computer (MDC) sources and internal radio communications. The CSTMC will revisit the needs following implementation of the plan to try to determine moving to level four if necessary for additional weather information resources.

2.4.2 Use of External Weather Information Resources

This item pertains to the use of weather information resources generated by weather service providers external to the CSTMC. The use of external weather information resources for level 3 requires road weather information to be reported to the TMC on scheduled intervals from field observations or instrumentations located within the right-of-way or roadway environment. The reports will provide weather information that covers all routes within the TMC jurisdiction to aid in decision making processes. These data will include road conditions, current weather conditions and past weather conditions.

Based on the steps listed in the five integration dimensions for levels 1-3, the CSTMC will, as in use of internal weather information, need to identify the staff member(s) to be trained on the RWIS data. A supervisor at the Street Department has offered his assistance to provide the training on RWIS data. With all the weather information available the CSTMC will need to identify which information will be utilized and how it will be processed. The thresholds also need to be established for when to start considering a signal timing modification, and a procedure will need to be established describing that threshold and the implementation. The signal timing modification to recall will be easy enough to determine based on failure of video camera detection. The challenge will be creating a modified signal timing plan based on adverse road conditions. A pilot test on modified signal timing during inclement weather can help determine if any addition equipment costs will be necessary or if the existing sources of information collection and sharing with the CSTMC are sufficient.

The CSTMC could expand to a level four with a contract to provide weather forecasts targeted specifically at the TMC operational needs. There are major budget cuts including personnel in both 2009 and 2010, and a fee based contract would be prohibitive with so many city employees being permanently eliminated. So unless a free service is provided or a grant is obtained to pay for such a contracted service, there is no possibility of paying for a contracted service with the existing CSTMC budget.

2.4.3 Availability of Weather Information

The weather data provided by surface transportation weather forecast vendors will allow the TMC to better manage traffic during adverse weather. The TMC will have data when needed to make informed decisions regarding weather conditions.

Based on the steps listed in the five integration dimensions for levels 1-4, the CSTMC will need to determine how to display the radar and/or satellite information in the TMC. There might not be any additional costs utilizing the existing computer monitors or video wall to display the weather data. One challenge in implementing this approach has to do with the how busy the TMC becomes with adverse weather conditions and the increase in traffic crashes. Depending on the number of operators working, it can sometimes become overwhelming to just keep up with the constant changes involving the traffic and crash situations. Having someone free to obtain and or display the weather data and make decisions could even be more challenging.

2.4.4 Frequency of Weather Forecasts

Weather forecasts can be provided at different frequencies during a given time period. The frequency with which a forecast is provided reflects the level of information detail that is required by the TMC for decision making, and higher frequencies involve a more sophisticated forecast generation and forecast utilization. This is usually a progression from a discrete level to a higher level and not necessarily an accumulation of all the individual components of the prior levels. Frequency of forecasts range from a per-request basis to hourly resolution weather forecasts.

The frequency of weather forecasts at the proposed Level 3 will extend the features of a general condition weather forecast by permitting a refinement of the forecasted weather conditions several times a day with new forecasts. The value of these forecasts still will be limited as the detail provided is limited in content. TMC operations would use the periodic forecasts to more frequently adjust traffic operations in response to variations in forecasted weather conditions.

Based on the steps listed in the five integration dimensions for levels 1-3, the CSTMC would need to establish a procedure for distribution of the weather forecast within the TMC. This procedure will also need to identify the person(s) responsible to collect the data and additionally deal with after-hours weather forecasts. The center will need to establish performance measures to assess the utilization of frequent forecast information. The CSTMC should not have any expenditure costs for this item.

2.4.5 Frequency of Road Weather Observations

This item pertains to the frequency of data acquisition and generally reflects the value and level of utilization within an operational environment. The frequency of road weather observations at the proposed Level 3 will combine the standard hourly flow of weather observations to include identification of critical operational situations when weather observations exceed thresholds predefined by TMC personnel. This will enable TMC staff to quickly identify locations and weather situations that are most critical to the TMC daily operations.

Based on the steps listed in the five integration dimensions for levels 1-3, the CSTMC will also need to determine the frequency for distribution of the road weather observations in addition to identifying the person(s) responsible to collect the data. Additionally, dealing with after-hours road weather observation is an issue. The center will also need to establish performance measures to assess the utilization of weather and road weather observations. The CSTMC should not have any expenditure costs for this item.

2.4.6 Weather Information Coordination

This item involves the exchange of information to support decision-making and operations within a TMC. The weather information coordination at level 2 will build an intra-TMC weather information coordination committee with a staff member assigned to coordinate weather information activities within the TMC, or assign a single staff member to explore the same issues as the intra-TMC committee with an additional responsibility to perform ongoing efforts to better identify and address weather needs..

Based on the steps listed in the five integration dimensions for levels 1-2, the CSTMC would need to establish training for the TMC staff on weather information in addition to establishing some coordination with the local metrological community. The CSTMC should not have any expenditure costs for this item.

2.4.7 Extent of Coverage

Extent of coverage for level 3 will require the CSTMC to expand the coverage of weather information devices to provide information about weather conditions from multiple locations in a specific corridor. The information will be obtained from specific locations in the corridor known to experience traffic problems caused by weather conditions. Examples of strategies that could be implemented with this level of deployment include coordinated signal timing plans to promote traffic movement on an emergency or evacuation route and deploying diversion routing around a flooded section of roadway. Weather information will need to be tightly coupled with traffic information from the corridor. This level of integration will be needed to support automated traffic management responses.

Based on the steps listed in the five integration dimensions for levels 1-3, the CSTMC would need to expand the extent of coverage. An additional 80 cameras are in the process of being installed over the next few years which will help in the citywide coverage by use of cameras. There are projected expenditures for the camera purchase and installation which are already part of a grant. There are no plans for street sensors which would be the responsibility of the Street Department which like all general Colorado budgets have been drastically reduced for 2010.

2.4.8 Interaction with Meteorologist

This item pertains to interaction with meteorologists by TMC personnel and provides opportunities to learn more about how to incorporate weather information in TMC operations.

Interaction with Meteorologist at level 2 will require the development of a check list of routine weather awareness activities. In this strategy the focus group or informal gatherings of local professionals in the transportation management and weather communities will pursue activities to heighten the awareness of mutual interests, needs, and challenges in surface transportation weather. These activities will result in the development of a structured check list of routine weather awareness efforts that will be addressed as a shared activity.

Based on the steps listed in the five integration dimensions for levels 1-2, the CSTMC will need to establish the necessary guidelines for communication between the TMC staff and the weather community. There should not be any costs associated with this item.

2.4.9 Alert Notification

This item pertains to providing an information exchange process to heighten awareness of weather-related operational issues. The alert notification for level 3 will replace the telephone call system with a manual email or paging system. Operators in the TMC will send email alerts of developing or impending weather events to key responders. The advantage of this type of system over a telephone call list is that multiple individuals can be notified simultaneously thereby decreasing the time it takes to notify key individuals. Individuals needing more information can then contact the TMC to obtain more detailed information about the impacts and threats caused by the weather event. The CSTMC will determine the type and extent of alert notifications that are possible from the traffic control cabinet lid and the different failures from which notifications are possible for weather related events.

Level 4 would include automated road weather system-generated notifications. This would be a costly upgrade to any existing systems in place and would be cost prohibitive, and for that reason level 4 was not considered.

Based on the steps listed in the five integration dimensions for levels 1-3, the CSTMC would need to establish which weather events would trigger TMC action on signal timing modifications and how those notifications are made. The creation of a procedure is necessary to identify the steps for the notification process. The costs should be minimal to implement the alert notification.

2.4.10 Decision Support

This item pertains to the use of weather information to make effective transportation management/operations decisions. The decision support for level 2 will require TMC response personnel to meet with other stakeholders and responders and develop a series of pre-defined advisory, control, and treatment responses to be performed during specific weather events. These predefined responses will be incorporated into the standard operating procedures of the TMC, and operators will have ready access to these responses, either through the use of flip cards or other documentation. Weather event thresholds will be defined that trigger specific types of responses by the TMC operators.

Based on the steps listed in the five integration dimensions for levels 1-2, the CSTMC would need to establish once again the weather events that would trigger TMC action on signal timing modifications and determine how those notifications are made. The criteria to identify the change in street conditions that will allow the TMC to revert back to the normal signal timing plan must also be established. This will require the establishment of a protocol on when these decisions are made and who will make the decisions. The timing technicians will need to determine the appropriate time plan(s) for the adverse weather conditions. The expense will mostly be in man-hours to establish the appropriate timing plans to implement during the adverse weather conditions.

2.4.11 Weather/Road Weather Data Acquisition

This item pertains to the level of technological sophistication used to process and manage weather data. The weather/road weather data acquisition will have TMC operators access weather information not only from external sources but also from agency owned and operated weather monitoring stations to acquire road weather information. Weather monitoring devices will be installed at strategic locations and will allow the operator to access detailed weather information from specific locations. Depending upon the extent of coverage, information could be from scattered locations or an entire region or area. This level will require a more extensive communications network to bring back the weather information from the remote sensors to the TMC.

Based on the steps listed in the five integration dimensions for levels 1-3, the CSTMC would need to develop algorithms that monitor City owned and operated weather information sources on a periodic basis. Procedures need to be established on the use of the information.

3 IMPLEMENTATION OF INTEGRATION PLAN

The plan for the CSTMC is the creation of operator initiated signal timing plans based on weather observations and predictions. The process involves utilizing the City of Colorado Springs Street Department grid map shown in Figure 1-2 and performing signal timing modification in each of the 16 grids. It is also a future goal to develop an automated modified signal timing plan in any or all of the 16 grids for weather related incidents. The automation can help reduce the need for after- hour staffing to manage the system.

The CSTMC has elected to conduct a pilot program and the timeline is outlined in Section 3.1 below. The pilot project implementation will officially start in January, 2010. The plan is to utilize just a single grid from the 16 grids available. The project will include fine tuning and evaluating the signal timing plan in the grid selected. At the completion of the pilot project the signal timing plans can be implemented in all 16 grids.

3.1. Implementation Schedule (Phasing and Sequencing)

The tasks are split into two categories. One is the weather integration related tasks and the other is traffic signal timing pilot project tasks. Each task and the time frame for both start and completion are listed below in table 3-1.

Table 3-1 Implementation Tasks and Time Frames

ID	Weather Integration Related Tasks	Start	Finish
A1	Collect baseline data in specified locations/grids	12/09	03/10
A2	Refine concept of operations and identify what weather information is needed	01/10	02/10
A3	Obtain training for weather coordinator	01/10	02/10
A4	Establish data triggers, notifications and actions	02/10	05/10
A5	Make adjustments to TMC displays to include cameras, radar and satellite	05/10	07/10
A6	Prepare standard operating procedures	08/10	09/10
A7	Alert notification to the motorist on weather conditions	ongoing	

ID	Traffic Signal Timing Pilot Project Related Tasks	Start	Finish
B1	Identify performance measures and prepare plan	04/10	05/10
B2	Develop signal timing plans based on new weather information	05/10	08/10
B3	Provide training for signal technicians on new procedures	09/10	10/10
B4	Implement signal timing pilot project with automation	11/10	03/11
B5	Evaluate effectiveness	11/10	05/11

3.2 Cost Estimates

Nearly all expenditures will be in personnel. The increased workload for the CSTMC personnel will be absorbed into the normal work schedule. Since the number of staff hours necessary for implementation will not be done on overtime, there will be no hard cost expenditures.

3.3 Operations and Maintenance Requirements

The operations and maintenance requirements for implementation should be feasible with the CSTMC personnel.

3.3.1 Staffing

It is anticipated that the existing staff at the CSTMC should be sufficient to handle the increased work load for both the implementation and maintenance of signal timing plans for adverse weather condition.

3.3.2 Training

There will be two components of training during implementation. One session of training involves operational training for a TMC operator in the area of gathering and evaluating the weather information. The other involves developing and providing training for the traffic signal technicians on the development of traffic signal timing plans based on adverse weather conditions.

3.4 Anticipated Challenges and Constraints of Integration

There will be some challenges facing the CSTMC for implementation. Recent budget cuts for Colorado Springs have reduced the number of traffic signal technicians assigned. This staffing reduction has already increased the individual workload for each of the remaining assigned traffic signal technicians. Another challenge will be weather-related and having a sufficient number of adverse weather days to implement and test the modified signal timing plans after they are created. An additional challenge and constraint has to do with budget reduction in 2010 and 2011, and any unexpected expenditure during implementation could hamper the implementation timeline.

3.5 Possible Future Activities

The CSTMC identified some desirable activities for the future should funding become available. The activities include contracting with an outside source for tailored road weather forecasts, obtaining streaming information from maintenance vehicles into the TMC, adding additional RWIS in key locations, extending TMC hours and the necessary staffing, and expanding out to include other weather events such as fog to include in the signal timing plan modification. The CSTMC will also revisit the Guide in approximately a year or two to see if other possible weather integration strategies and or levels should be pursued.

Wyoming Department of Transportation

Statewide Transportation Management Center (TMC)

WEATHER INTEGRATION PLAN

December 15, 2010

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We wish to thank all those involved with the development of this plan; for their contributions both to this plan as well as their contributions to the plan development process.

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Tim McGary, P.E., District Maintenance Engineer, WYDOT
Captain Bill Morse, Patrol Dispatch Supervisor, WYDOT
Cliff Spoonemore, P.E., Winter Research Services, WYDOT
Vince Garcia, P.E., GIS/ITS Program Manager, WYDOT
Chris Cluett, Research Leader, Battelle
Fred Kitchener, McFarland Management
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ABBREVIATIONS AND ACRONYMS

ASOS	Automated Surface Observing Systems
ATMS	Advanced Traffic Management System
AVL	Automatic Vehicle Location
AWOS	Automated Weather Observing Systems
DMS	Dynamic Message Signs
ECAR	Enhanced Citizen-Assisted Reporting
EOC	Emergency Operations Center
ESS	Environmental Sensor Station
FHWA	Federal Highway Administration
HAR	Highway Advisory Radio
ITS	Intelligent Transportation Systems
MDC	Mobile Data Computer
MDSS	Maintenance Decision Support System
OEM	Office of Emergency Management
RWIS	Road Weather Information System
RWMP	Road Weather Management Program
SALECS	State Law Enforcement Communications System
TMC	Transportation Management Center
VSL	Variable Speed Limit
WHP	Wyoming Highway Patrol
WIM	Weather Information Manager
Wx	Weather
WYDOT	Wyoming Department of Transportation

1. Introduction

1.1 Background

The Federal Highway Administration's (FHWA) Road Weather Management Program (RWMP) has established a programmatic road map that identifies the integration of weather information into the operations of Transportation Management Centers (TMCs) across the country as a key objective. Integrating weather information supports the capability of state and local transportation agencies to better manage their traffic, dispatch maintenance crews and respond appropriately and in a timely way to weather-induced problems affecting the transportation system. Well-integrated weather information allows TMC operators to make effective and timely management and operational decisions based on quality information related to weather forecasts, the anticipated timing and intensity of weather events, and the interaction of weather conditions with the road surface. Integrated weather information positions a TMC to be proactive rather than reactive with regard to the operations and maintenance of their transportation infrastructure. The FHWA has prepared a detailed self-evaluation "Guide" that assists TMCs in identifying appropriate weather integration strategies, given their current level of weather integration and where they would like to be with regard to enhanced integration and to prepare a weather integration plan based on strategies suggested by the self-evaluation.

1.2 Purpose

The WYDOT Statewide Transportation Management Center (TMC) was chosen by the FHWA to conduct a weather information integration self-evaluation and planning process (using a provided Guide) and provide feedback. The Guide was prepared in an electronic form (Microsoft Access) that walks the user through several sections to eventually result in the identification of potential weather information integration strategies that a TMC may consider for future enhancements to their operations. The WYDOT Statewide TMC was chosen because of their strong interest in improving their use of weather information in support of their operations and to better manage the extreme weather events experienced throughout the state. The TMC was asked to review the Guide and provide feedback that will be used to improve the Guide. As part of this activity, WYDOT was asked to develop a weather integration plan. This document is that plan.

Since the jurisdiction for WYDOT's TMC is statewide, this plan was undertaken as part of an effort to develop a weather integration strategy for the entire state of Wyoming. In addition, this effort was to aid developers with the final design of the FHWA's Weather Integration Self-Evaluation and Planning Guide.

1.3 TMC Overview

WYDOT's statewide TMC became operational in the Fall of 2008. The TMC is housed in the basement of the Qwest building at 6101 Yellowstone Road in Cheyenne, Wyoming, approximately a mile north of the WYDOT headquarters complex. The TMC houses both the emerging Intelligent Transportation Systems (ITS) operations function and a new dispatch center for the Wyoming Highway Patrol.

Source: Courtesy C. Cluett, Battelle

Figure 1 – TMC Building Exterior

Source: Courtesy WYDOT Public Affairs Office

Figure 2 – TMC Operations Room

While numerous states already have similar TMCs in operation to deal with urban traffic congestion, Wyoming's center is geared almost exclusively toward rural travel management and information needs that result from extreme weather conditions. Additionally, it is one of the few TMCs where communication services for DOT construction, traffic, and maintenance functions are co-located with law enforcement.

1.4 Key Functions of WYDOT's TMC

The functions of the TMC have expanded over time, but the core functions can be grouped into the following four main areas:

- **Monitoring and control of roadside ITS devices** such as web cameras, road weather information systems (RWIS), variable speed limit (VSL) signs, dynamic message signs (DMS), highway advisory radios (HAR), flashing beacons, and road closure gates;

- **Serving as a law enforcement communications hub** for state and federal agencies by maintaining frequent contact with Highway Patrol troopers and other personnel via the State Law Enforcement Communications Systems (SALECS);

- **Managing communication with the traveling public** via the 511 Travel Information Service (telephone and internet components) and direct contact with media outlets, visitor centers, and truck stops;

- **Receiving and relaying road and weather reports** from volunteers participating in the Enhanced Citizen-Assisted Reporting (ECAR) program, as well as, dispatching WYDOT construction and maintenance crews throughout the state.

1.5 Weather Integration Self-Evaluation Process

WYDOT was first introduced to the Weather Information Integration Self-Evaluation and Planning Guide on April 22nd, 2009. On May 18th, 2009, WYDOT conducted a meeting to work through the Guide with a team of stakeholders from WYDOT Maintenance, Winter Research Services, the Transportation Management Center, Highway Patrol Dispatch, and the National Weather Service. During this two-hour meeting, the stakeholders worked their way through the Guide, answering the questions collectively as a group. The stakeholders included the following individuals:

Chad Hahn, Senior Forecaster, National Weather Service, Cheyenne
Ken Shultz, P.E., State Maintenance Engineer, WYDOT, Cheyenne
Tim McGary, P.E., District Maintenance Engineer, WYDOT, Laramie
Captain Bill Morse, Patrol Dispatch Supervisor, WYDOT, Cheyenne
Cliff Spoonemore, P.E., Winter Research Services, WYDOT, Cheyenne
Vince Garcia, P.E., GIS/ITS Program Manager, WYDOT, Cheyenne
Kevin Cox, P.E., ITS-Systems Engineer, WYDOT, Cheyenne

Selected output from the Guide is included in the appendices.

1.6 Relationship to Other Plan Documents

This section lists current and proposed documents that help guide the TMC's practices and operations. Along with the name of each document is a brief description of its relationship to this Weather Integration Plan.

Wyoming Statewide Intelligent Transportation (ITS) Architecture - This document produced by WYDOT was published in April 2006. It updated the previous ITS Strategic Plan that WYDOT had been operating under since 2002. This document serves as a high-level guide for ITS infrastructure deployment, compliance with ITS standards, and multi-jurisdictional coordination. It relates to TMC weather integration by providing a good planning reference for future ITS deployments, and guidance on how WYDOT communicates with surrounding states during storm events.

WYDOT Transportation Management Center Concept of Operations – This document produced by WYDOT was adopted in March 2005. It was the primary planning document used to design, build and staff WYDOT's TMC. This document represented the culmination of several years work to identify the TMC requirements and the entire systems engineering process. This document is relevant to the TMC weather integration because it provides several examples of operational scenarios that involve winter weather maintenance and traveler information.

Variable Speed Limit (VSL) Policy Memorandum – This policy has been developed over the past two years to provide WYDOT with an interim process by which appropriate speeds can be determined and posted on VSL signs. The current policy relies heavily on speed sensor data for determining speed, but the TMC operators, Highway Patrol, and maintenance personnel also use whatever weather information is available to assist in establishing an appropriate speed for conditions.

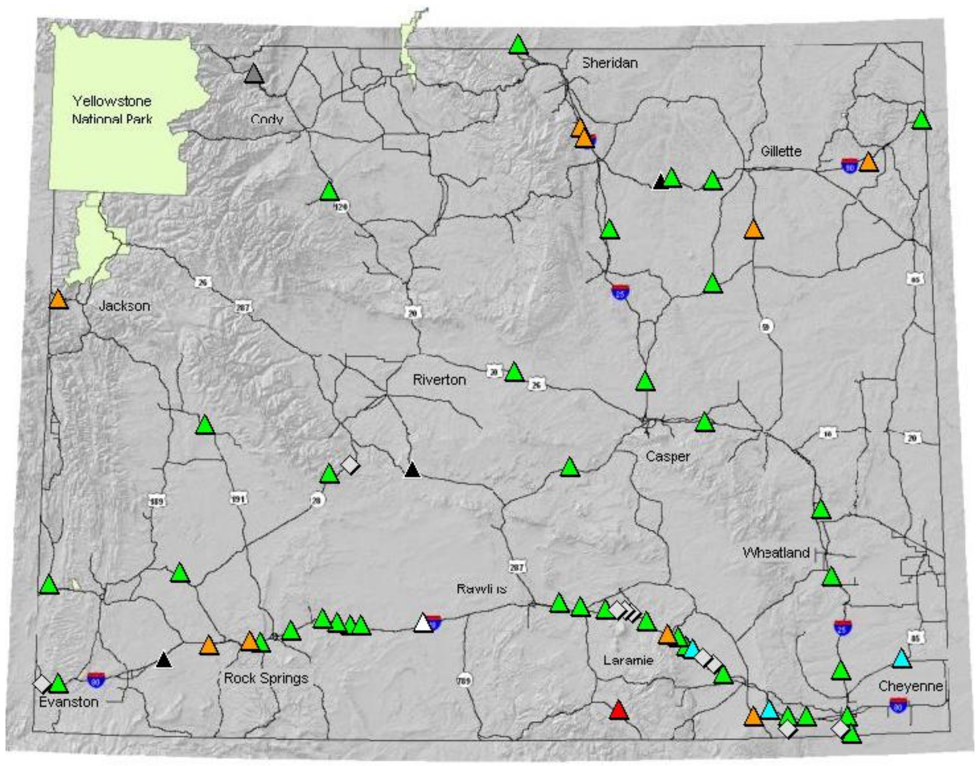
Proposed VSL Control Strategy – This document and process is still being developed by the University of Wyoming. When complete, this document will provide the necessary documentation to implement a sound practice for WYDOT to use to post speed limits on VSL signs. Preliminary reports indicate that this control strategy will require input from both speed sensors and RWIS stations to determine appropriate speed limits. The way in which WYDOT manages weather information within the TMC will be fundamental to the development of this process and this document.

High Wind/No Light Trailer Alerting Policy – This is a policy established by the TMC and district maintenance personnel simply to establish definitive, consistent thresholds for posting either high wind conditions, or advising no light trailers.

2 Existing Road Weather Management Systems

2.1 RWIS Infrastructure

Currently, WYDOT has a network of 62 RWIS stations located throughout the state. They are managed by a central software system known as SCAN Web. The two figures that follow are screen shots from that software, showing the statewide network, followed by a more detailed map of southeast Wyoming where WYDOT has deployed greater density of RWIS for a 52-mile VSL corridor between Laramie and Rawlins. Between the two figures is a table listing the RWIS locations statewide.



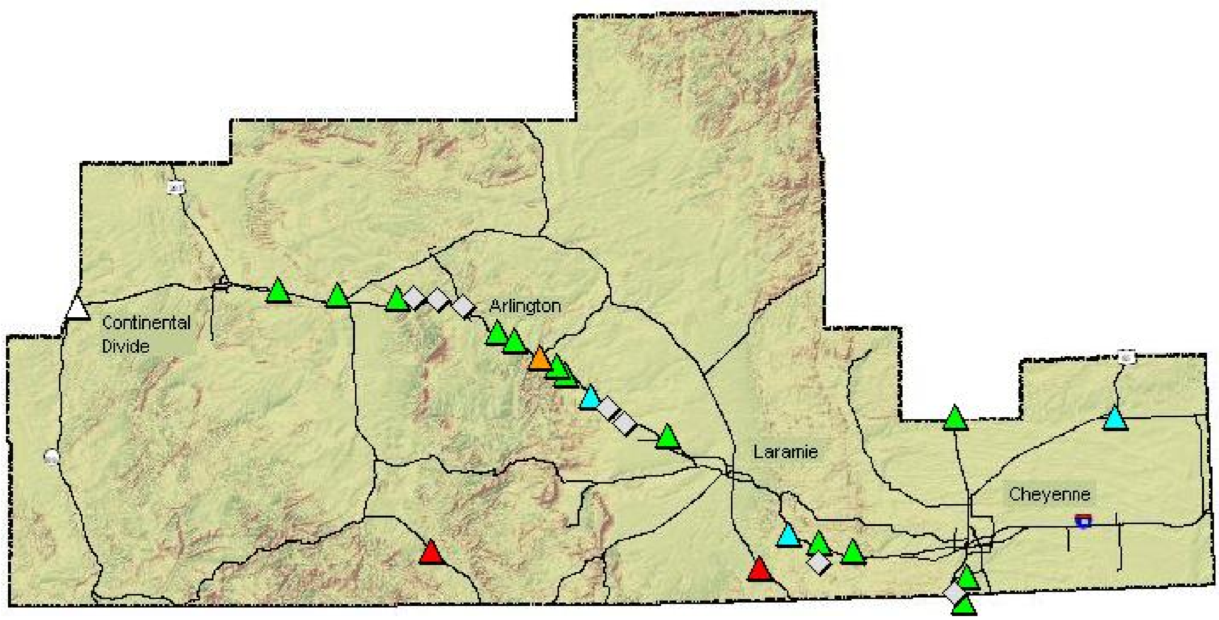
Source: Screenshot of ScanWeb Map Image

Figure 3 – RWIS locations statewide

Table 1 – List of RWIS Locations

RWIS No.	SITENAME	Highway	MILEPOST
1	Wyo Hill	I - 25	3.52
2	Whitaker	I - 25	30.2
3	Bordeaux Interchange	I - 25	70.8
4	Coleman	I - 25	98.7
5	Deer Creek	I - 25	164.2
6	Twenty Mile Hill	I - 25	207.2
7	I-25 Divide	I - 25	267.3
8	Evanston	I - 80	4.2
9	First Divide	I - 80	13.86
10	Church Butte	I - 80	52.65
11	Peru Hill	I - 80	82.31
12	Green River Tunnel East	I - 80	90.5
13	Rock Springs West	I - 80	97.9
14	Baxter Road	I - 80	111.5
15	Superior	I - 80	124.5
16	Point of Rocks	I - 80	129.8
17	Bitter Creek	I - 80	141.83
18	Tipton	I - 80	156.72
19	Continental Divide	I - 80	184.3
20	Sinclair	I - 80	221.7
21	Walcott Junction	I - 80	234.66
22	Dana Ridge	I - 80	244.8
23	Mile Marker 249.1	I - 80	249.1
24	Halleck Ridge	I - 80	252.16
25	Elk Mountain	I - 80	256.17
26	County Road 402	I - 80	262
27	Wagonhound	I - 80	266.58
28	Foote Creek	I - 80	269.5
29	Arlington	I - 80	271.8
30	Arlington East	I - 80	273.85
31	Cooper Cove	I - 80	279.36
32	Strouss Hill	I - 80	283.75
33	Quealy Dome	I - 80	289.5
34	Herrick Lane	I - 80	297.66
35	Summit East	I - 80	325.8
36	Vedauwoo	I - 80	329.4
37	Vedauwoo	I - 80	329.4
38	Remount	I - 80	340.5
39	Montana Line	I - 90	0.1
40	Piney Creek North	I - 90	43.7
41	Piney Creek Interchange	I - 90	44.7
42	Indian Creek Rd	I - 90	83.3
43	Dead Horse	I - 90	91.5
44	Mile Marker 108	I - 90	108
45	Inyan Kara	I - 90	170.5
46	Beulah Interchange	I - 90	205.9
47	Rim	US - 191	127
48	Hiland	US - 20/26	57.4
49	Pumpkin Vine	US - 287	420.4
50	Beaver Rim	US - 287 / WY 789	48.1
51	Sage Junction	US - 30	34
52	Gun Barrel	US - 85	46.8
53	Meeteetse Rim	WY - 120	61.5
54	Teton Pass	WY - 22	11.2
55	Pathfinder	WY - 220	80.1
56	Skyline	WY - 230	113.2
57	South Pass	WY - 28	41.4
58	Red Canyon	WY - 28	59.5
59	Chief Joseph	WY - 296	32.96
60	Shute Creek	WY - 372	36
61	Pine Tree Junction	WY - 387	131.79
62	Belle Fourche	WY - 59	87

The VSL corridor is the first of its kind in Wyoming. It consists of a 52-mile stretch of Interstate 80 from Walcott Junction (20 miles east of Rawlins) to Quealy Dome Interchange (17 miles west of Laramie). In that 52-mile corridor, WYDOT now has 13 RWIS stations. This project represents the first corridor-level RWIS deployment in WYDOT's history.



Source: Screenshot of ScanWeb Map Image

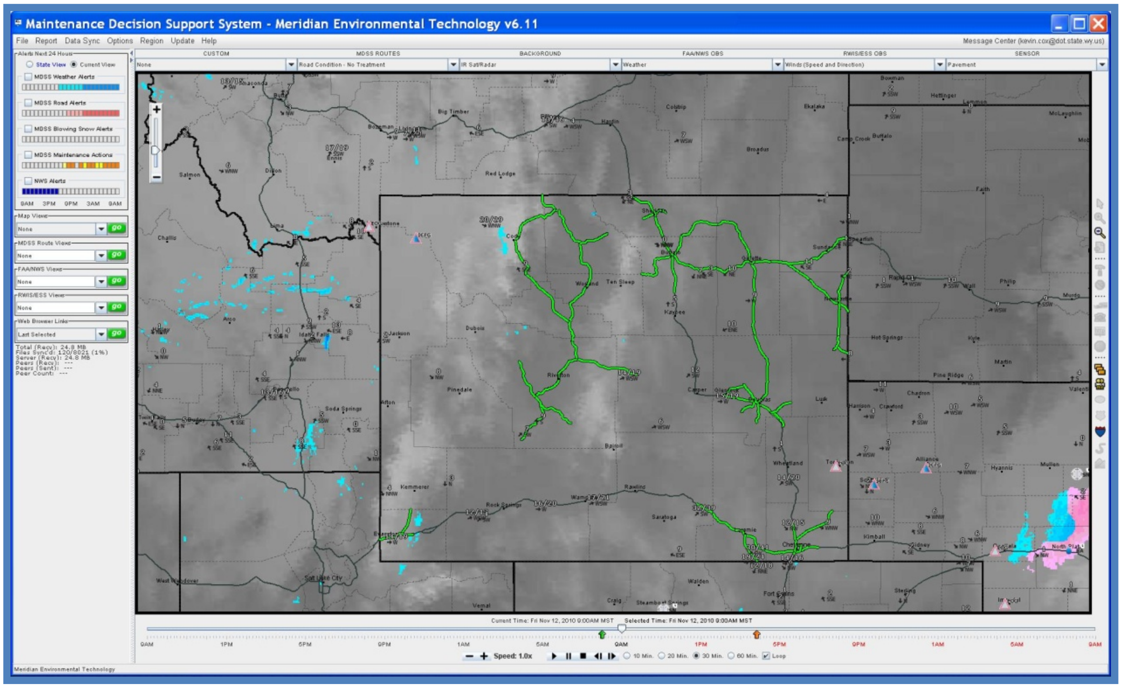
Figure 4 – RWIS in southeast Wyoming

RWIS maintenance statewide is primarily conducted by WYDOT forces with the exception of an annual maintenance contract to assist WYDOT forces with the annual preventive maintenance. Annual maintenance costs for WYDOT RWIS are estimated at about $4,000 per site for WYDOT.

2.2 Maintenance Decision Support System

Over the past several years, WYDOT has participated in the FHWA pooled-fund study to deploy a maintenance decision support system (MDSS). That product is currently being used by WYDOT as provided by Meridian Environmental Technologies. The extent to which it is used within the TMC has been somewhat limited, but is beginning to emerge as a useful tool for the TMC operators in road weather condition status and forecasting.

There is no formal guideline in place for using MDSS in WYDOT's day-to-day operations. Several maintenance crews use the system. However, there is no coordinated effort within WYDOT for how best to use this tool either within the TMC or between the TMC and maintenance. The TMC intends to put this system to better use in the future. Figure 5 below is an image of the MDSS graphical user interface.



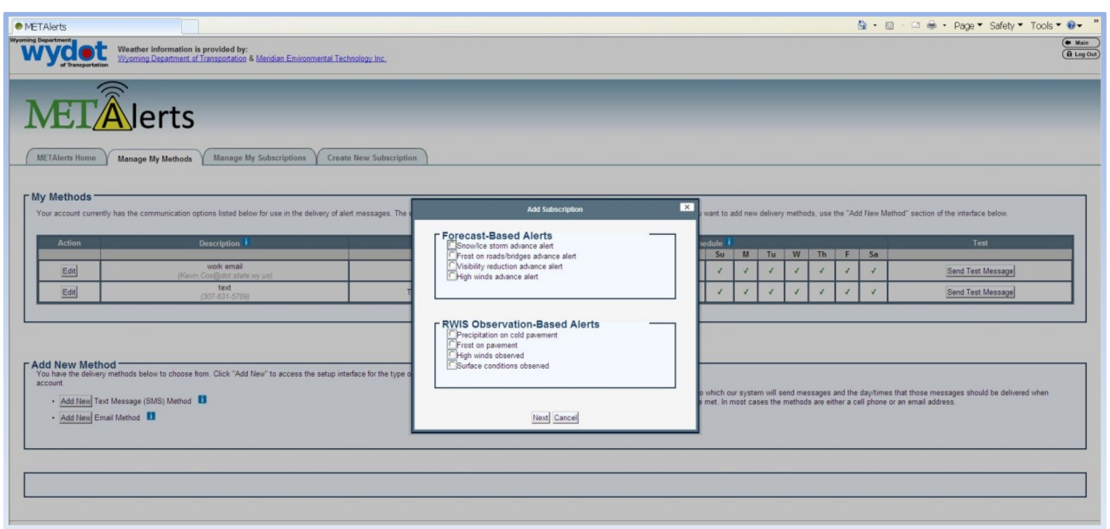
Source: Screenshot of MDSS, Meridian Environmental Technology

Figure 5 – MDSS User Interface

2.3 Alert Notifications

Another product of the MDSS system is known as METalert. It provides current and forecast weather alerts based on individual user-defined thresholds for counties, cities, or individual RWIS stations. WYDOT has just deployed this system, and made it available to TMC operators and maintenance personnel. Below is a screen shot from the application showing the types of alert notifications available.

The alerting system provides for either e-mail or text message notifications, and has quite a few variables for criteria threshold selection. However, the limitation of this system is that it doesn't provide pop-up alerts on the TMC operators' computer screens.



Source: Screenshot of WYDOT METAlerts System

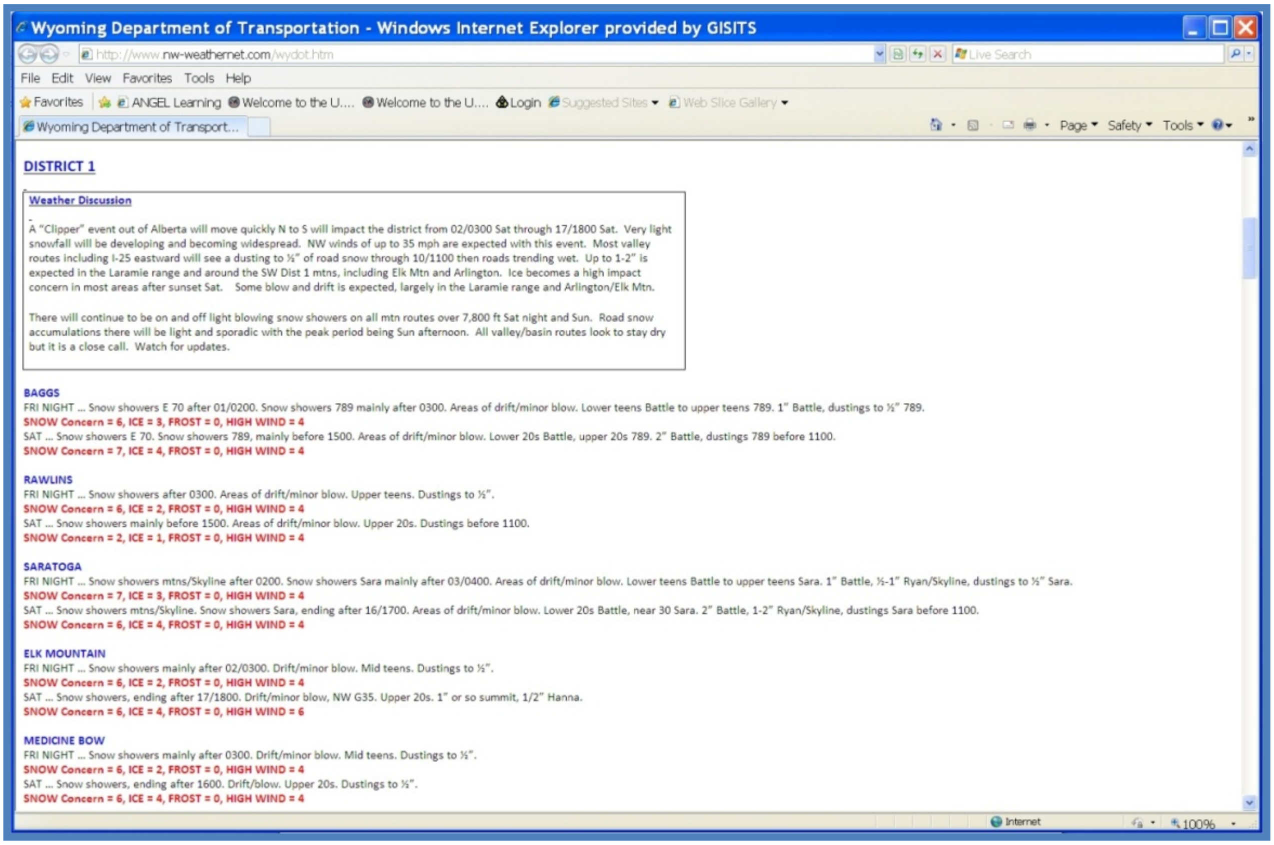
Figure 6 – Weather Alerting System

In the past, WYDOT had used SCAN Sentry alerting system which is part of the overall SCAN Web RWIS management package used to monitor WYDOT's RWIS. There has not been much success in implementing that into the TMC due to configuration issues with setting reasonable thresholds. The complaint from the TMC operators has been that it sends repetitive alerts for the same condition. Further investigation will be conducted to see if appropriate parameters can be established for that alerting system.

2.4 NorthWest Weathernet

NorthWest Weathernet is the forecasting service WYDOT maintenance forces have used for several years. The service consists of a text-based twice daily forecast hosted on a website. It provides forecasts based on WYDOT's maintenance shop locations. This format has proven to be very useful for the maintenance foremen and plow operators because they can easily scroll down to their shop location, and get an up-to-date forecast for their area. The format has proven to be more cumbersome from the TMC's statewide or even sometimes district-wide perspective.

Below is a sample screen shot of the product provided by NorthWest Weathernet, Inc.



Source: Screenshot of WYDOT NorthWest Weathernet

Figure 7 – NorthWest Weathernet WYDOT page

2.5 Other TMC Weather Resources

Numerous other sources of weather information are currently being used within the TMC. Most of these are in the form of websites such as Intellicast, the Weather Channel, or the National Weather Service. Additionally, there is a television in the TMC which is oftentimes tuned to the Weather Channel, or a national or local news channel which occasionally show weather information.

3 Concepts of Operations

In terms of operational concepts for using weather within the TMC, very few formal guidelines or written policies exist. There are some established thresholds from RWIS stations that require action in terms of notifying maintenance or the public of conditions.

Conceptually, the TMC attempts to manage weather at two levels, statewide and/or corridor.

3.1 Statewide Weather Management

The TMC is the only entity at WYDOT that attempts to, or has the responsibility to manage weather from a statewide perspective. Although there are many weather information resources, no single group or person within the TMC is tasked with managing weather information and providing a strategy to handle it statewide. In effect, the TMC still has a WYDOT legacy tendency to operate as five separate maintenance districts. However, the TMC offers WYDOT's best promise for strategic management of weather events.

3.2 Laramie to Cheyenne (The Summit) Commuter Corridor

This corridor along Interstate 80 was WYDOT's first corridor-level deployment of ITS equipment back in 2003. Additional equipment has been deployed in this corridor since 2003. Today, the ITS equipment in this 20-mile stretch includes: six cameras, ten dynamic message signs, three RWIS stations, and twelve speed sensors. With the density of DMS signs in this corridor, the TMC is able to provide traveler information in a slightly different manner. Essentially, information can be provided in a more location-specific manner as to road and weather conditions. The treacherous nature of this corridor has made it a candidate for one of the next three VSL corridors in the state.

3.3 Variable Speed Limit Corridor

WYDOT's first VSL corridor is a 52-mile stretch of Interstate 80 located in the south central part of the state between the towns of Rawlins and Laramie. The VSL signs for the corridor became operational February 13th, 2009. In their first 14 months of use, they have proven to offer some very positive results in terms of number and severity of accidents, and number and length of closures.

The corridor consists of 14 VSL locations (seven in each direction). Vehicle speeds are monitored by side-fire radar detectors at 18 locations, and central control software provides average speeds for all vehicles every 30 seconds. The speeds are displayed on a map using color-coded icons and highway segments that change color based on the average observed speeds. Additionally, 13 RWIS sensors provide real-time weather information, including surface status, visibility, wind, humidity, air temperature and surface temperature.

3.3.1 Current Policy/Procedure

The current policy for posting speed limits was developed in a cooperative effort amongst the TMC, Highway Patrol, and the District Maintenance personnel. The policy is lengthy, and describes the procedures for posting speeds based on the situation, and the personnel available at the time of posting a speed limit change.

The policy does allow TMC operators to reduce the speed based on a sustained speed reduction of at least 10 MPH for at least 15 minutes. The TMC operators primarily use speed data to make this decision, but also refer to RWIS data as supporting information.

3.3.2 Draft Control Strategy

WYDOT's ITS Program is currently working with the University of Wyoming's Civil Engineering Department to come up with a control strategy that would automate, and make better use of the speed and weather data to provide TMC operators with a quality recommended speed based on the information available from these sensors. The control strategy is in its early phases of development, and the draft version will begin to be tested this Fall.

4 Integration Needs

After completing the self-evaluation "interview" process, 11 high priority needs were identified as shown in Table 2 below. There were also seven medium priority needs, and two low priority needs. As the group evaluated the needs and their levels, it became apparent that by addressing the high priority needs, most of the medium and low priority needs would be addressed. (See Appendix D)

The sections below describe the 11 high priority needs, and group them into four main "need" areas.

Table 2 – High Priority Needs

Need Areas	**Definition of Need**
Advisory Operations	
Weather Information Dissemination	Disseminate weather information to a larger set of stakeholders and users in the region (including transit and other modes)
Institutional Coordination	
Written Policy Development	Develop and implement clear, written policies and procedures for handling weather events.
Coordination within TMC	Improve coordination within the TMC
Coordination with Adjacent Jurisdictions	More coordinated responses and information with adjacent jurisdictions/regions
Treatment Operations	
Level of Service Restoration	Reduce the time required to restore pre-event level of service operations after a weather event
Weather Management Response	Improve the timeliness of weather management response including deployment of field personnel and equipment
Weather Information Processing and Gathering	
Interpreting Weather Information	Assistance in interpreting weather information and how best to adjust operations in light of that information.
Improving Weather Information Coverage	Improve the coverage and granularity of weather information in the region.
Better Real-Time Information On Road Conditions	Better real-time information on road conditions during weather events.
Better Prediction of Weather Event Impacts	Better prediction of impact of weather events including assessment of reduction in capacity.
Better Short-Term Forecasts	Better short-term forecasts of arrival time, duration, and intensity of specific weather events at specific locations.

5 Integration Solutions

The “Levels of Integration” matrix (see Figure 8 on the following page) shows where WYDOT’s TMC is today (highlighted in yellow), and where it needs to be following integration (highlighted in pink). This matrix represents recommendations directly from the Self-Evaluation Guide.

The six items of integration shown in gray are the six broad areas where WYDOT’s TMC needs to improve from its current level of integration to a proposed level of integration in order to effectively integrate weather into its operations. The sections below give more detail on each of these integration areas, and offer proposed solutions on how that integration might be accomplished.

5.1 Frequency of Road Weather Observations

This integration item can best be addressed by expanding the frequency of real-time reports from individuals traveling on Wyoming highways, including, but not limited to plow drivers, the commercial trucking community, and other members of the traveling public.

Presently, snow plow operators call the TMC when either conditions change, or two hours have passed. The TMC could benefit from the implementation of a system that notifies when each currently active plow has passed the two-hour report timeframe.

Additional reporting could come from other travelers on WYDOT’s highways, assuming that they have been properly trained to identify conditions, and how to pass that information to the TMC.

5.2 Weather Information Coordination

As can be seen from the levels of integrations matrix, this item of integration has the biggest gap in terms of where WYDOT currently is (highlighted in yellow), and where WYDOT would ultimately like to be in terms of TMC weather integration. Consequently, most of the initial implementation efforts of this plan will focus in this broad area of weather information coordination.

WYDOT plans to at least partially address this need immediately by contracting with a part-time local meteorologist (DayWeather, Inc.) to perform weather information management tasks in the TMC. This initial contract began in early December 2010 and will extend for a trial period through May 31st, 2011.

5.3 Extent of Coverage

Until this past year, WYDOT had a scattered network of approximately 32 RWIS stations throughout the state. With the implementation of the first VSL project, WYDOT found it necessary to increase the coverage of real-time weather information, and implemented its first corridor-level RWIS deployment, installing 13 RWIS in a 52-mile stretch of interstate.

Item of Integration (Broad Requirement)	Levels of Integration					
	None	**Level 1**	**Level 2**	**Level 3**	**Level 4**	**Level 5**
Use of Internal Weather Information Resources	None	Camera imagery	Radar, satellite, ASOS and AWOS data, and general zone-type forecast information	**Level 2 data plus data from RWIS and related networks**	Level 3 data plus data from AVL/MDC sources and internal radio communications	Level 4 data with addition of analyzed fields & transformed data parameters (frost index, wind chill,snow,ice,water depth
Use of External Weather Information Sources	None	General weather information, forecasts, and interpretation provided through media as irregular service (radio and TV weather)	Internet provided, public access general forecasts, weather radar or satellite image or weather-specific broadcast channel	Field observers or probes providing scheduled weather / driving condition information from entire route system	**Contractor provided surface transportation weather forecasts targeted at the operational needs of the TMC agencies**	Direct connection between private weather information service providers and traffic management software
Availability of Weather Information	None	Cable channel or subscription weather information vendor providing general weather information	Internet provided weather radar or satellite image on video wall	Field observers or ESS network providing scheduled road or driving condition reports	**Vendor provided daily surface transportation weather forecasts and observed weather conditions incl Level 3**	Meteorologist, located within TMC, forecasting and interpreting weather
Frequency of Weather Forecasts	None	Receive weather forecast information on a request basis	Receive weather forecast once daily.	Receive periodic forecasts several times a day	**Receive hourly weather forecasts several times a day**	Receive continuous updates of weather forecasts in real-time
Frequency of Weather/Road Weather Observations	None	Receive information of weather conditions on a request basis	***Receive weather observations once hourly***	**Level 2 plus receive weather/road weather observations when predefined threshold has been exceeded**	Receive weather/road weather observations every ten minutes and when predefined thresholds have been exceeded	Receive weather/road weather observations continuously with data above predefined thresholds highlighted
Weather Information Coordination	***None***	Intra-TMC committee tasked with weather information coordination	Identified TMC or member tasked w/ coordinating weather information at TMC	**Dedicated weather operations supervisor**	Meteorology staff located within the TMC forecasting and interpreting weather info.	Co-location of the EOC/OEM
Extent of Coverage	None	Sparse set of isolated locations	***Network of scattered locations***	Corridor-level	**Multiple-corridor/sub-regional**	Regional/statewide
Interaction with Meteorologists	None	***Focus group or informal gatherings of local professionals from the transportation management and weather communities***	Develop check list of routine weather awareness activities	**Periodic staff meeting that includes a meteorologist to discuss weather information needs and responses**	With a meteorologist present conduct post-event debriefing / regular assessment to fine-tune responses	Daily personal briefings and integrated interruptions by meteorology staff within the TMC
Alert Notification	None	Monitor media outlet, Internet page, or data stream for critical events	Telephone call list	***Manual email/paging system***	**TMC road weather system (RWIS / ALERT / FEWS) generated specific notification**	Automatic notification through Center-to-Center communications
Decision Support	None	***Ad-hoc implementation of weather management strategies***	Use quick-reference flip cards on operator's workstation to implement predefined response	**Response scenarios through software-supplied solutions w/ projected outcomes based on weather / traffic modeling**	Automated condition recognition & advisory/control strategy presented to operator for acceptance into ATMS	Automated condition recognition and advisory or control strategy implemented without operator intervention
Weather/Road Weather Data Acquisition	None	Media reports	Internet and/or satellite data sources	Across agency intranet and dedicated phone acquisition	**Dedicated communications link to state, federal, private data sources**	Dedicated communications link to state, federal, private data sources incl vehicle weather data

Figure 8 – Integration Levels Matrix

This deployment is likely the beginning of many more of its kind in Wyoming. Presently, there are three more VSL projects in the design phase for WYDOT, and one currently under construction.

The TMC is struggling to manage this corridor-level information, and needs to improve its ability to effectively use this more granular information to identify problems, and help establish appropriate speed limits.

5.4 Interaction with Meteorologists

The TMC currently has two very good resources that allow for direct communication with a meteorologist. The first is provided by a direct telephone number to a staff meteorologist at NorthWest Weathernet, Inc., and the second is either by phone or radio to the National Weather Service meteorologist located in Cheyenne. Both of these resources are currently under-utilized by the TMC. With the addition of a Weather Information Manager on the floor of the TMC, coordination with these resources should improve greatly.

5.5 Alert Notifications

Although WYDOT is presently at integration level 4 on this item, work still remains to enhance our current MetAlert system. Work also remains to attempt redeployment of SCAN Sentry on the TMC operator workstations. Lastly, WYDOT is also going to pursue the development of its own weather information tool that can be tailored to include current and forecast road weather conditions. Part of that tool will include a system to provide alert notifications.

5.6 Decision Support

Two of the biggest decisions TMC operators face on a minute-by-minute basis are determining appropriate DMS messaging and VSL speed postings. Through the use of weather and traffic information, a decision model integrated into WYDOT's advance traffic management system (ATMS) could prove to be an effective means of providing timely, accurate, and consistent messaging and posted speeds on WYDOT's DMS and VSL, respectively.

6 Implementation of Integration Plan

6.1 Summary of Integration Strategies

Shown below (Table 3) is a summary of WYDOT's integration strategies. The table shows WYDOT's current level for each integration item, the recommendation from the self-evaluation guide, the integration level selected by WYDOT for both the current (C) timeframe, and future (F) timeframe, and comments for each integration item.

Table 3 – Summary of Integration Strategies

Integration Item	Current Integration Level	Guide Recommended Integration Level	Chosen Weather Integration Level (C/F)*	Rationale/Comments
1: Use of Internal Weather Information Resources	3	3	3/4	C=expand RWIS locations; F=outfit & receive data from plows & other vehicles
2: Use of External Weather Information Resources	4	4	4/4	Build integrated weather information tool to assist TMC operators
3: Availability of Weather Information	4	4	4/4	Availability meets current needs
4: Frequency of Weather Forecasts	4	4	4/4	Frequency meets current needs
5: Frequency of Weather/Road Weather Observations	2	3	3/3	Expand coverage and frequency of plow driver reports
6: Weather Information Coordination	None	3	3/3	Contracting with a part-time local meteorologist to perform weather information management tasks in TMC.
7: Extent of Coverage	2	4	4/5	C=Adding four more VSL corridors throughout the state; F=continued expansion of RWIS sites.
8: Interaction with Meteorologists	1	3	4/5	See item 6 above.
9: Alert Notification	4	4	4/4	Enhance alert notification in phases (use SCAN Sentry, expand METalert , build new alert system w/ new Wx info tool).
10: Decision Support	1	3	3/4	C=automated recommendations for VSL system; F=expand to DMS recommendations.
11: Weather and Road Weather Data Acquisition	4	4	4/5	C=continue current acquisition; F=automated data collection from DOT vehicles.

* C/F=**C**urrent plans (within next 1-2 years)/**F**uture plans (beyond 2 years)

6.2 Implementation Tasks

The integration strategies can be grouped into the following seven implementation tasks or projects:

1) **RWIS Expansion** - Expand RWIS coverage throughout state, and multiple corridor RWIS projects. We will start by doing a gap analysis, and seek input from District Maintenance offices to determine desired locations. With that, WYDOT can develop an RWIS expansion plan, and budget for new RWIS on an annual basis to complete the desired expansion in approximately the next five years.

2) **AVL/MDC** - Expand vehicle weather data transmission to TMC from plows with AVL/MDC. This will include continued deployment of our current AVL system statewide. For the MDC component, WYDOT will use its systems engineering process to ensure all requirements are met, including integration with the current AVL system.

3) **Weather Information Manager (WIM)** - Employ part time, contracted meteorologist as weather information manager. This individual will help implement much of this plan, assist the TMC operators in managing and utilizing current and future weather information, and provide a primary point of contact for all weather information resources within WYDOT.

4) **VSL Expansion** - Add VSL in four locations and continue to expand in statewide corridors. One of these four new corridors is currently under construction and scheduled to be complete by January 2011. Two more of these four will be operational by October 2011, and the fourth corridor is currently schedule to be constructed in 2012.

5) **Weather Information Tool** - Build integrated weather information tool to assist operators. Deploy portions of this for commercial vehicle and general public use. The weather information manager will be instrumental in developing this system. They will also be the one responsible for keeping the information in this tool timely and accurate.

6) **Weather Alert Notification** - Expand/enhance alert notification system in phases: 1) using SCAN Sentry 2) expanding METalert system 3) using the new integrated weather integration tool/database. SCAN Sentry is presently available to the TMC, it just needs some fine tuning on the configuration and some additional training for the operators. METalert is also available, but additional features (e.g. visibility alerts) could be very useful for the TMC operators.

7) **ATMS Decision Support** - Expand decision support tools, starting with VSL and moving to DMS recommendations. This will include some software development work for our existing ATMS to provide such recommendations based on weather and traffic information.

6.3 Integration Timeline and Cost Estimates

The table below shows the seven projects identified in the previous section, an estimated start time and end time for each, an estimated implementation cost, and an estimated operations and maintenance cost.

Table 4 – Project Timeline and Costs

Project	Start	Completion	Initial Cost	O&M Cost
RWIS Expansion	Ongoing	2015	$ 2,000,000	$ 400,000/year
AVL/MDC	2011	2017	$ 800,000	$ 100,000/year
WIM	Ongoing	N/A	N/A	$ 100,000/year
VSL Expansion	Ongoing	2014	$ 3,000,000	$ 200,000/year
Wx Info Tool	2011	2013	$300,000	$15,000/year
Wx Alert Notification	Ongoing	2013	$20,000	$3,000/year
ATMS Decision Support	2011	2013	$150,000	$15,000/year

The good news is that most of these projects are underway and at least partially funded. At this point, the scopes of these projects may need to be slightly re-defined to meet the needs identified in this plan.

6.4 Anticipated Challenges and Constraints

As shown in Table 4 above, four of the seven projects are already ongoing, and reasonably funded. The AVL project is also underway, but there is no clear direction yet on the mobile data computer (MDC) aspect of that project. Integrating an MDC with the AVL system WYDOT is currently in the process of deploying could prove to be challenging.

The weather information tool will be a fairly challenging undertaking, but many of the components are already in-place to facilitate some of that system. Again, integration of multiple information resources will be the challenge with this project.

Lastly, WYDOT currently has an off-the-shelf ATMS. Tailoring this system to meet the needs of our VSL and DMS decision support could prove to be a difficult task. This software is provided by a third party vendor and their ability to tailor the software to the TMC's needs remains an unknown at this point.

Appendix A – Summary Report of Weather Events

Summary report of weather events experienced by your TMC (Section 1 Report)

Weather Event	Frequency	Extent	Impact
Tornadoes	Seldom	Local/Isolated Spots	Significant Impact
Blowing Sand or Dust	Occasional	Areawide	Significant Impact
Flooding	Occasional	Statewide	Significant Impact
Sleet, and Freezing Rain	Occasional	Areawide	Significant Impact
Blizzard or White-out	Regular	Statewide	Significant Impact
Blowing Snow	Regular	Statewide	Significant Impact
Bridge Frost, Road Frost	Regular	Statewide	Significant Impact
Drizzle and Light Rain	Regular	Statewide	Little Impact
Flurries and Light Snow	Regular	Statewide	Little Impact
High Winds	Regular	Regional	Significant Impact
Moderate to Heavy Rain	Regular	Statewide	Little Impact
Moderate to Heavy Snow	Regular	Statewide	Moderate Impact
Severe Thunderstorms	Regular	Regional	Significant Impact
Smoke, Mist, Fog, Smog or Haze	Regular	Regional	Significant Impact

Appendix B – Summary Report of Impacts Due to Weather Events

Summary report of impacts due to your weather events (Section 2 Report)

Weather often impacts the activities of transportation system operators working to maintain safety and mobility. Making sense of weather information along with recognizing the benefits of its application beyond the simplest case is not a trivial task. As a generalization, TMC operators tend to be more responsive and take action based on their observations of traffic impacts rather than responding directly to weather information. It is important to understand the nature of weather impacts on capacity and speed reductions, impacts on safety (e.g., crash risk/frequency, incident management including Safety Service Patrols that are often dispatched from or coordinated with TMCs), and impacts on institutional coordination (i.e., need for communication between traffic managers and maintenance personnel, traffic managers and emergency management personnel, traffic managers and law enforcement personnel) to ensure that the self-evaluation and the integration solutions address the right concerns. The ability to estimate impacts could presumably lead to managing freeway systems and arterial signal systems using advisory, control and treatment strategies efficiently.

This report identifies the impacts of these weather events on your TMC's traffic operations considering both impacts to users as well as operators

Traffic impacts commonly associated with the weather events in your region.

Weather Event	Increased Travel Times	Increased Crash Risk	Reduced Roadway Capacity	Traffic Management Device Impairment	Disruption of CVO or specialized vehicle operations	Road Closures
Drizzle and Light Rain	□	■	□	□	□	□
Moderate to Heavy Rain	■	■	□	■	□	□
Severe Thunderstorms	■	■	■	■	■	■
Flooding	■	■	■	■	■	■
Flurries and Light Snow	□	■	□	□	□	□
Moderate to Heavy Snow	■	■	■	■	■	■
Blizzard or White-out	■	■	■	■	■	■

Sleet, and Freezing Rain	■	■	■	■	■	■
High Winds	■	■	■	□	■	□
Blowing Snow	■	■	■	■	■	■
Blowing Sand or Dust	■	■	□	■	□	□
Smoke, Mist, Fog, Smog or Haze	■	■	■	■	■	■
Tornadoes	■	■	■	■	■	■
Bridge Frost, Road Frost	■	■	■	□	■	□

Roadway impacts commonly associated with the weather events in the region

Weather Event	Slick Roads	Road Obstruction	Structural deterioration	Presence of debris	Low visibility	Others (Please specify)
Drizzle and Light Rain	■	□	□	□	□	
Moderate to Heavy Rain	■	■	□	□	■	
Severe Thunderstorms	■	■	■	■	■	
Flooding	■	■	■	■	□	
Flurries and Light Snow	■	□	□	□	□	
Moderate to Heavy Snow	■	■	□	□	■	
Blizzard or White-out	■	■	□	□	■	
Sleet, and Freezing Rain	■	□	□	□	■	
High Winds	□	□	■	■	■	
Blowing Snow	■	■	□	□	■	

Blowing Sand or Dust	■	□	□	■	■
Smoke, Mist, Fog, Smog or Haze	□	□	□	□	■
Tornadoes	□	■	■	■	□
Bridge Frost, Road Frost	■	□	□	□	□

Specific impacts of weather events in your region on TMC operations

LEGEND
4 - Significant Impact, 3 - Moderate Impact, 2- Little Impact, 1 - No Impact

Weather Event	Increased use of equipment and labor	Increased in-house labor	Increased contractor labor	Loss of communications /power	Changes in traffic control operations	Others Significant Impacts
Drizzle and Light Rain	1	1	1	1	1	
Moderate to Heavy Rain	2	2	1	1	2	
Severe Thunderstorms	3	2	1	3	3	
Flooding	2	2	1	1	2	
Flurries and Light Snow	2	2	1	1	2	
Moderate to Heavy Snow	3	3	1	2	3	
Blizzard or White-out	4	4	1	2	4	
Sleet, and Freezing Rain	3	3	1	2	2	
High Winds	3	2	1	2	3	
Blowing Snow	4	4	1	2	4	
Blowing Sand or Dust	2	1	1	1	2	
Smoke, Mist, Fog, Smog or	3	3	1	1	3	
Tornadoes	2	1	1	3	2	
Bridge Frost, Road Frost	2	1	1	1	3	

Appendix C – Summary Report on Current Integration Level

Summary report on your TMC's current level of weather integration (Section 3 Report)

Item of Integration I1 Use of Internal Weather Information Resources

☐	■	■	■	☐	☐
None	Camera imagery	Radar, satellite, ASOS and AWOS data, and general zone-type forecast information	Level 2 data plus data from RWIS and related networks	Level 3 data plus data from AVL/MDC sources and internal radio communications	Level 4 data with addition of analyzed fields and transformed data parameters (frost index, wind chill, est. snow, ice, water depth)

Item of Integration I2 Use of External Weather Information Sources

☐	■	■	■	■	☐
None	General weather information, forecasts, and interpretation provided through media as irregular service (radio and TV weather)	Internet provided, public access general forecasts, weather radar or satellite image or weather-specific broadcast channel	Field observers or probes providing scheduled weather / driving condition information from entire route system	Contractor provided surface transportation weather forecasts targeted at the operational needs of the TMC agencies	Direct connection between private weather information service providers and traffic management software

Item of Integration I3 Availability of Weather Information

☐	■	■	■	■	☐
None	Cable channel or subscription weather information vendor providing general weather information	Internet provided weather radar or satellite image on video wall or computer screen	Field observers or ESS network providing scheduled road or driving condition reports	Vendor provided daily surface transportation weather forecasts and observed weather conditions including level 3.	Meteorologist, located within TMC, forecasting and interpreting weather

Item of Integration I4 Frequency of Weather Forecasts

☐	■	■	■	■	☐
None	Receive information of weather forecasts on a request basis	Receive weather forecast once daily.	Receive periodic forecasts several times a day	Receive hourly updates of weather forecasts several times a day	Receive continuous updates of weather forecasts in real-time

Item of Integration I5 Frequency of Weather/Road Weather

☐	■	■	☐	☐	☐
None	Receive information of weather conditions on a request basis	Receive weather observations once hourly	Level 2 plus receive weather/road weather observations when predefined thresholds have been exceeded	Receive weather/road weather observations every ten minutes and when predefined thresholds have been exceeded	Receive weather/road weather observations continuously with data above predefined thresholds highlighted

Item of Integration I6 Weather Information Coordination

■	□	□	□	□	□
None	Intra-TMC committee tasked with weather information coordination	Identified TMC or maintenance staff member tasked with coordinating weather information at TMC or virtually linked to the TMC	Dedicated weather operations supervisor	Meteorology staff located within the TMC forecasting and interpreting weather information	Co-location of the EOC/OEM

Item of Integration I7 Extent of Coverage

□	□	■	□	□	□
None	Sparse Set of Isolated Locations	Network of Scattered Locations	Corridor-level	Multiple-corridor/sub-regional	Regional/Statewide

Item of Integration I8 Interaction with Meteorologists

□	■	□	□	□	□
None	Focus group or informal gatherings of local professionals from the transportation management and weather communities	Develop check list of routine weather awareness activities	Periodic staff meeting that includes a meteorologist to discuss weather information needs and responses	With a meteorologist present conduct post-event debriefing / regular assessment to fine-tune responses	Daily personal briefings and integrated interruptions by meteorology staff within the TMC

Item of Integration I9 Alert Notification

□	■	■	■	□	□
None	Monitor media outlet, Internet page, or data stream for critical events	Telephone call list	Manual email/paging system	TMC road weather system (RWIS / ALERT / FEWS) generated specific notifications (Email or page)	Automatic notification through Center-to-Center communications

Item of Integration II10 Decision Support

□	■	□	□	□	□
None	Ad-hoc implementation of weather management strategies	Use quick-reference flip cards on operator's workstation to implement predefined response	Response scenarios through software supply potential solutions with projected outcomes based on weather / traffic modeling	Automated condition recognition and advisory or control strategy presented to operator for acceptance into ATMS	Automated condition recognition and advisory or control strategy implemented without operator intervention

Item of Integration II11 Weather/Road Weather Data Acquisition

□	■	■	■	■	□
None	Media Reports	Internet and/or Satellite Data Sources	Across agency intranet and dedicated phone acquisition	Dedicated communications link to state, federal, private data sources	Dedicated communications link to state, federal, private data sources including vehicle-derived weather data

Appendix D – Summary Report on TMC Operational Needs to Be Addressed by Better Weather Integration

Summary report on your TMC Operational Needs that could be addressed by better weather integration (Section 4 Report)

Rating Legend: 3 - High, 2- Medium, 1-Low, 0 - No Need

Need Area / Rating	Need Statement
Advisory Operations	
3-High	Disseminate weather information to a larger set of stakeholders and users in the region (including transit and other modes)
2-Medium	Improve targeting of weather messages (site-specific; user group specific) to more effectively convey road weather information.
2-Medium	Provide better pre-trip weather condition information to aid travelers in their decision-making
2-Medium	Provide better en-route information on weather conditions to aid travelers in their decision-making
2-Medium	Improve message content (for DMS, 511, HAR, Web sites, etc.)
Institutional Coordination	
3-High	Develop and implement clear, written policies and procedures for handling weather events.
3-High	Improve coordination within the TMC
3-High	More coordinated responses and information with adjacent jurisdictions/regions
2-Medium	Improve coordination with local public safety and emergency agencies
1-Low	More opportunities and mechanisms for communications and exchange with others in the weather community and those with experience dealing with weather events.
Traffic Control Operations	
2-Medium	Improve management of emergency routing and evacuation for large-scale weather events
2-Medium	Improve traffic diversion and alternate routing capabilities
0-No Need	Improve traffic signal timing during weather events to facilitate traffic movement
0-No Need	Improve safety at intersections during weather events
Treatment Operations	
3-High	Reduce the time required to restore pre-event level of service operations after a weather event
3-High	Improve the timeliness of weather management response including deployment of field personnel and equipment
2-Medium	Reduce costs of roadway treatment options
1-Low	Need to assist maintenance in determining the optimal treatment materials, application rates, and timing of treatments.

Need Area	
Rating	**Need Statement**
Weather Information Processing and Gathering	
3-High	Assistance in interpreting weather information and how best to adjust operations in light of that information.
3-High	Improve the coverage and granularity of weather information in the region
3-High	Better real-time information on road conditions during weather events
3-High	Better prediction of impact of weather events including assessment of reductions in capacity
3-High	Better short-term forecasts of arrival time, duration, and intensity of specific weather events at specific locations

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