Best Practices for Road Condition Reporting Systems

Synthesis Report

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16. Abstract

Often, the center of an agency's traveler information system is a Road Condition Reporting System (RCRS). The RCRS is frequently the focal point, populated by manual and automated data and information feeds, supplying information to various information dissemination mechanisms. While the potential benefits of an RCRS are obvious, there are also costs of associated with the development, management, and support of the software system as well as costs associated with the operator time to perform entry. The benefits and costs are impacted by many institutional and technical issues that operations managers must face. This report presents a synthesis of current industry practices regarding the design, development, operation, maintenance, and use of RCRSs.

This report compiles information received through a survey and interviews with transportation agencies throughout North America to understand the uses of RCRSs and to identify industry practices that have delivered benefits to the agencies operating RCRSs. A total of 49 Current RCRS Industry Practices, 7 Best Practices, and 3 Emerging Best Practices are described in this report.

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Preface

We would like to acknowledge the following Transportation Management Center Pooled-Fund Study (TMC PFS) members for their contributions, support and technical guidance during this project.

Paul Keltner	Wisconsin DOT
Jeff Galas	Illinois DOT
Ron Fuessel	Texas DOT
Davis Behzadpour	Kansas DOT
Vinh Dang	Washington State DOT

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Executive Summary

In 2014, every state department of transportation (DOT) operated some form of traveler information dissemination system. The most common dissemination mechanism is a public website, but others include 511 phone systems, social media outlets, and mobile applications. Similarly, field devices such as Dynamic Message Signs (DMS) and Highway Advisory Radio (HAR) deliver en-route traveler information. Often, the center of an agency's traveler information system is a Road Condition Reporting System (RCRS). The RCRS is often the focal point, populated by manual and automated data and information feeds, supplying information to various information dissemination mechanisms.

While the potential benefits of an RCRS are obvious, there are also costs associated with the development, management, and support of the software system, as well as costs associated with the operator time to perform entry. The benefits and costs are impacted by many institutional and technical issues that operations managers must face. This report presents a synthesis of current industry practices regarding the design, development, operation, maintenance, and use of a RCRS.

Research Approach

An on-line survey of transportation agencies throughout North America was conducted to understand the uses of a RCRS and to identify industry practices that have delivered benefits to the agencies operating a RCRS. The first half of the survey questions focused on identifying which RCRS system an agency is using, how long they have been using it, and any significant changes made to the RCRS. The second half of the survey focused on the data received by an agency's RCRS (how data is entered, how frequently the data is updated, and what sources the RCRS receives data).

Following the survey, a series of one-on-one phone calls and in-person meetings were conducted to hear first-hand descriptions of what the agencies consider to be the industry practices that most benefited their RCRS operations. The research team worked closely with the Transportation Management Center (TMC) Pooled Fund Study (PFS) members, sharing the information as it was received through a series of milestone deliverables. Results were compiled in this report.

Summary of Key Findings

Current Industry Practices, Best Practices, and Emerging Best Practices

A total of 49 industry practices for the design, development, maintenance, and use of a RCRS were identified and documented. As part of the synthesis of information, 7 'best practices' were identified. Each best practice is a culmination of several related industry practices. The distinguishing factor between industry and best practices is that the best practices are those activities with the greatest benefits described or those practices that were deployed by multiple agencies, demonstrating benefits to each agency.

The 7 'best practices' identified are:

1. RCRS automated ingest of law enforcement CAD data;
2. Combining RCRS entry with other activities;
3. RCRS ingest of weather data;
4. Integrating lane closure databases into a RCRS;
5. RCRS events trigger of field device messages;
6. Generating automated performance measure data; and
7. Development and operation collaboration.

In addition, this project identified three 'emerging best practices' that describe a set of industry practices used by multiple agencies who have experienced recognized benefits. What differentiates these from best practices is that they have only recently been introduced or the long term approach has not yet been as established as the best practices.

Benefits

Agencies that operate a RCRS already recognize many benefits. Some benefits of RCRS use include:

- A structure that allows one central repository of data and information describing all types of events that can feed multiple information dissemination mechanisms;
- Multiple users within different agencies can enter and edit events in one central RCRS, allowing for the fusion of data and dissemination of traveler information that includes multiple jurisdictions;
- RCRSs often locate events against an established road network, allowing for events to be described according to their starting and ending points along the highway, enabling automated spoken announcements, text displays, or map displays of events;
- RCRSs can serve as a clearinghouse, allowing data and information sharing with other traveler information providers who will disseminate the information to their customers; and
- As travelers' expectations have changed with new technologies and the use of mobile devices, RCRSs have provided an easy transition into information delivery that now includes social media outlets. Looking toward the future, whatever the next generation information dissemination approaches are, RCRSs will most certainly provide the common clearinghouse of information.

The key findings of this research are the benefits that those agencies that currently operate RCRSs or are planning to operate RCRSs might experience if they deploy the practices described in this report. The descriptions of each industry practice included in this report identify potential benefits for each practice.

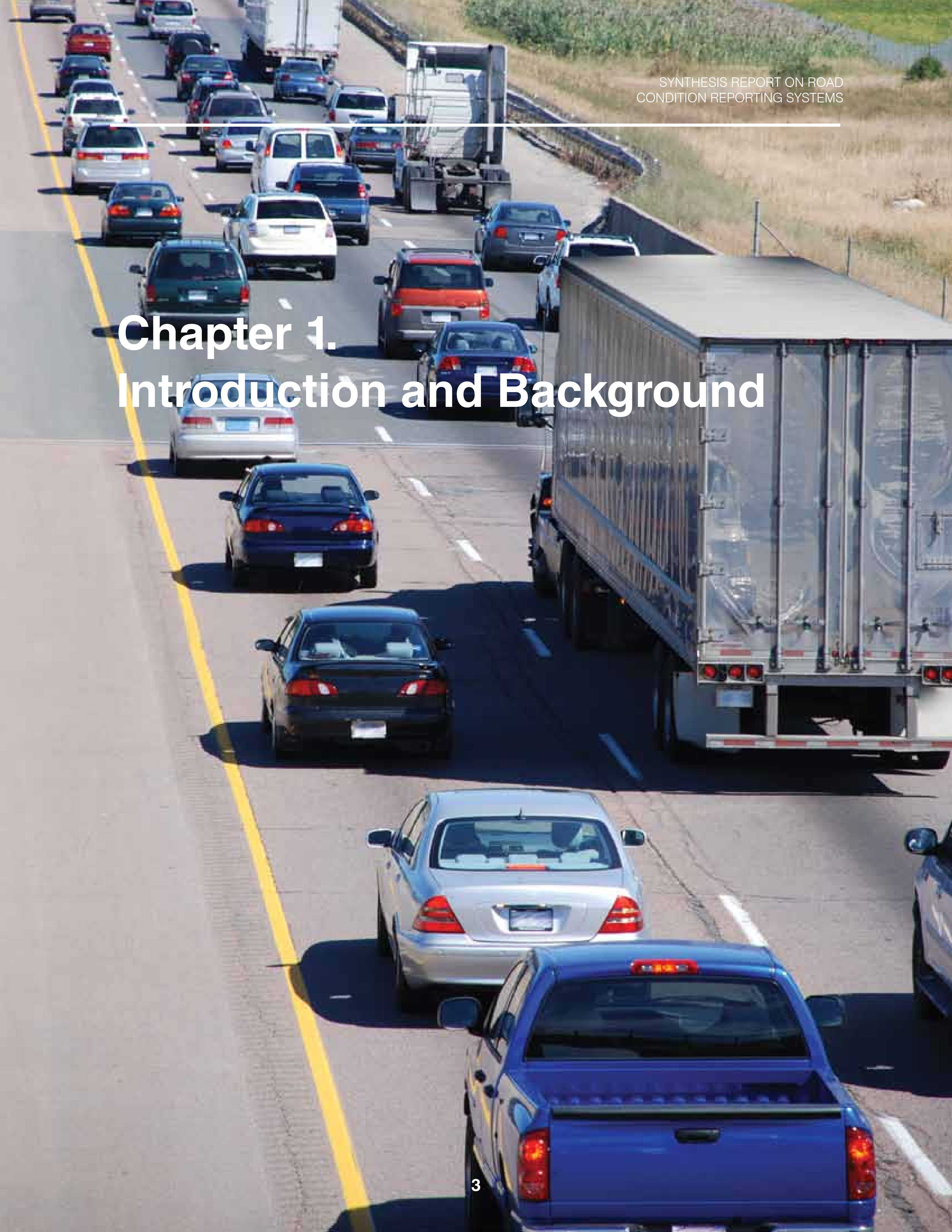
The benefits common to nearly all the industry practices presented in this report are:

- Reduced workload if the practice is implemented;
- Increased information content (coverage and detail);
- Improved timeliness of information assembly; and
- Reduced overall costs of RCRS management.

Intended Use of the Findings

The intended use of this document is to enable agencies operating an RCRS to understand the approaches that other agencies are taking to overcome challenges that are common to most agencies operating a RCRS. In some situations, the industry practices include software modules that automatically ingest data into the RCRS. Readers of this document might consider deploying such modules based on the experiences and benefits cited. Other industry practices describe approaches for developing and managing software changes. Readers of this document might consider alternate approaches to software development based on these experiences. Other industry practices describe partnerships with other public agencies or the traveling public to assemble more comprehensive information. Readers might take these suggestions and consider similar partnerships in their states.

Chapter 1.
Introduction and Background



Introduction to the Project

Project Objectives

In 2014, every state department of transportation (DOT) operated some form of traveler information dissemination system. The most common dissemination mechanism is a public website, but others include 511 phone systems, social media outlets, and mobile applications. Similarly, field devices such as Dynamic Message Signs (DMS) and Highway Advisory Radio (HAR) deliver en-route traveler information. Often, the center of an agency's traveler information system is a Road Condition Reporting System (RCRS). The RCRS is often the focal point, populated by manual and automated data and information feeds, supplying information to various information dissemination mechanisms.

While the potential benefits of an RCRS are obvious, there are also costs associated with the development, management, and support of the software system, as well as costs associated with the operator time to perform entry. The benefits and costs are impacted by many institutional and technical issues that operations managers must face.

This report presents a synthesis of current industry practices regarding the design, development, operation, maintenance, and use of a RCRS.

Research Approach

To complete this project, the research team began with an on-line survey of transportation agencies throughout North America to understand the uses of a RCRS and to identify industry practices that have delivered benefits to the agencies operating a RCRS. The first half of the survey questions focused on identifying which RCRS system an agency is using, how long they have been using it, and any significant changes made to the RCRS. The second half of the survey focused on the data received by an agency's RCRS (how data is entered, how frequently the data is updated, and what sources the RCRS receives data). The survey link was emailed to 51 recipients.

Following the survey, a series of one-on-one phone calls and in-person meetings were conducted to hear first-hand descriptions of what the agencies consider to be the industry practices that most benefited their RCRS operations. The research team worked closely with the Transportation Management Center (TMC) Pooled Fund Study (PFS) members, sharing the information as it was received through a series of milestone deliverables. Finally, the results were compiled in this report.

Intended Use of the Findings

The intended use of this document is to enable agencies operating an RCRS to understand the approaches that other agencies are taking to overcome challenges that are common to most agencies operating a RCRS. In some situations, the industry practices include software modules that automatically ingest data into the RCRS. Readers of this document might consider deploying such modules based on the experiences and benefits cited. Other industry practices describe approaches for developing and managing software changes. Readers of this document might consider alternate approaches to software development based on these experiences. Other industry practices describe partnerships with other public agencies or the traveling public to assemble more comprehensive information. Readers might take these suggestions and consider similar partnerships in their states.

Background of RCRS

The Role of Traveler Information

Commercial and leisure travelers are impacted by various conditions, including: weather, road conditions, roadwork, and congestion. Any of these conditions can impact the safety or efficiency of trips. Traveler information delivers real-time information about current and future conditions, and therefore helps improve the safety of trips, increase the mobility of travelers, and reduce overall traveler stress. From the perspective of the DOTs, traveler information also offers operational cost savings by reducing direct inquiries from travelers.

A quick review of traveler information websites or 511 phone systems in operation illustrates how much the traveler information industry has changed in the past 20 years. Travelers may now access information from their car, from their home or office, from mobile devices, and from roadside signs. The types of information travelers can access has increased as well. In some states, travelers can access real-time information on toll pricing, travel times, incident locations, road work, lane or road closures, transit departure times, parking availability, and special events, to name a few examples.

The Purpose and Evolution of RCRS

For agencies operating traveler information systems, the central clearinghouse of information behind the traveler information system is often a RCRS. As Figure 1 illustrates, an RCRS typically fuses data and information from various sources, providing one comprehensive source to feed a number of information dissemination mechanisms.

In the 1990s, the Arizona DOT was a pioneer in the operation of a statewide condition reporting system, referred to locally as the Highway Condition Reporting System (originally Highway Closure and Restriction System) (HCRS). This system allowed manual entry of road or lane closures, vehicle restrictions, roadwork, road conditions, and a variety of other events that might impact travel. Developed at a time prior to widespread Internet use, HCRS originally used designated computer terminals in the DOT regional offices, allowing authorized users from around the state to enter information. Arizona DOT also operated one of the first traveler information phone systems, disseminating the reports stored in HCRS to callers.

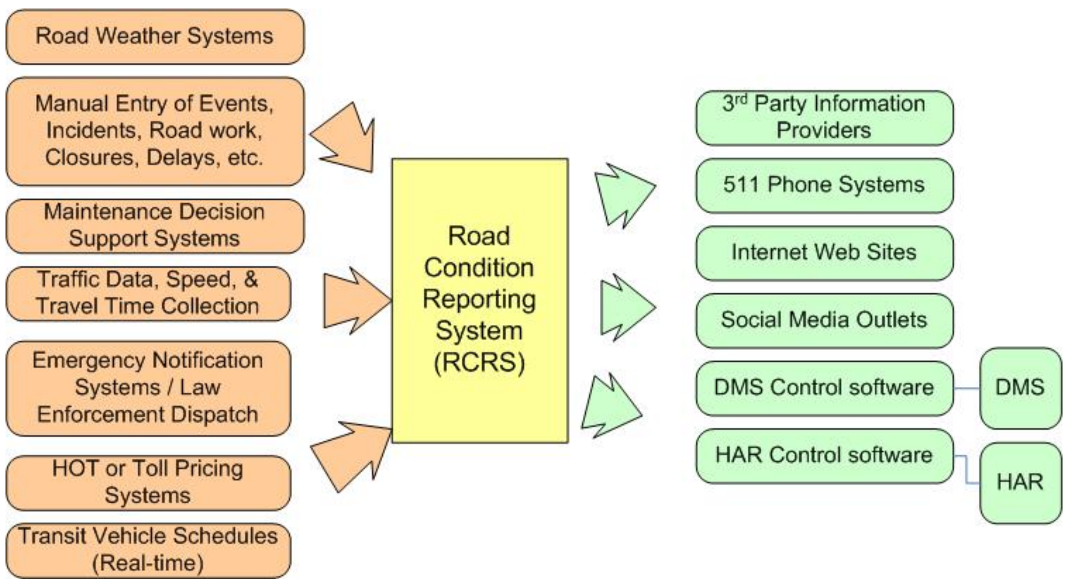


Figure 1. Illustration of a Conceptual RCRS

Eventually, the Internet served as a catalyst to both condition reporting systems and traveler information systems. Systems that already existed (such as the Arizona DOT HCRS) were converted to Internet based system, eliminating the need for dedicated entry terminals. Other states and local agencies developed first generation RCRSs. Now, in 2014, nearly every state DOT operates some form of RCRS. Some DOTs have developed their own RCRSs internally, other states have purchased vendor developed reporting systems or have contracted with vendors or universities to develop custom systems. Finally, there are examples of collaboration in the development and maintenance of condition reporting systems. This project surveyed public agencies, asking which RCRS they currently use. Surveys were sent to 51 agencies, 22 agencies replied to this survey. Respondents from thirteen (13) states indicated their RCRS was developed in house. Respondents from nine (9) states indicated use of vendor RCRS products.

RCRS Product	State
In-House	• Connecticut • Kansas • Maryland • Mississippi • Missouri • Montana • North Dakota • Ohio • Oregon • Pennsylvania • Tennessee • Vermont • Washington
Volt Delta	• Nevada
Transcore TranSuite ATMS	• Wisconsin • Utah
Open TMS – Open Roads Consulting Inc.	• West Virginia
Condition Acquisition Reporting Systems (CARS) – Castle Rock	• Idaho • Indiana • Maine • Minnesota
Lonestar	• Texas

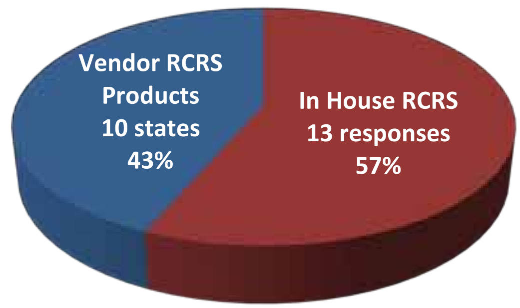


Figure 2. Responses for Question 3: What RCRS is your agency using?

An additional survey question asked agencies how long they have operated their RCRS. Respondents in six (6) states reported they have been operating their RCRS between 11 and 15 years and respondents in ten (10) states responded that they have been operating their RCRS between 6 and 10 years.

Number of Years Operating RCRS	State
1 to 5 years	• West Virginia
6 to 10 years	• Connecticut • Idaho • Indiana • Maine • Missouri • Ohio • Pennsylvania • Tennessee • Utah • Washington
11 to 15 years	• Iowa • Kansas • Minnesota • Mississippi • Oregon • Vermont
More than 16 years	• Maryland • Montana • Nevada • North Dakota • Texas • Wisconsin

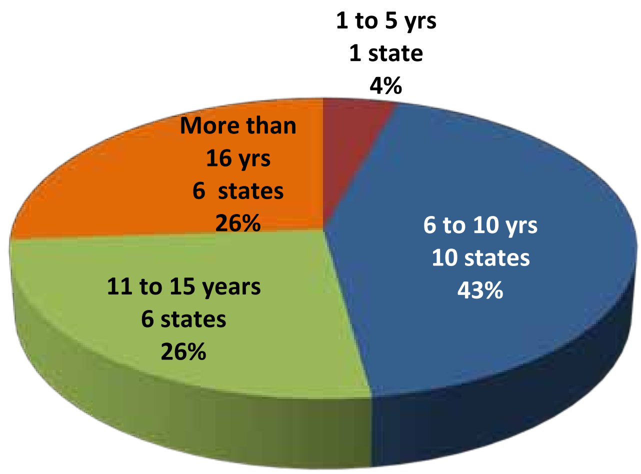


Figure 3. Responses for Question 4: How long has your agency operated a RCRS?

Industry Trends and Challenges Impacting RCRS Use

Federal Perspective

The US DOT Federal Highway Administration (FHWA) has supported multiple concepts that contribute to the national delivery of traveler information. In 1999 the US DOT petitioned the Federal Communications Commission (FCC) to designate a nationwide three digit telephone number for traveler information. The three digit number 511 was designated for traveler information in July, 2000, with the contingency that the progress towards a national number would be reviewed in 5 years.

Following the 511 designation, a group of agencies, including the American Association of State Highway and Transportation Officials (AASHTO), the American Public Transportation Association (APTA), the Intelligent Transportation Society of America (ITS America) and USDOT established the 511 Deployment Coalition with the goal of helping to encourage timely establishment of a national 511 traveler information service that is sustainable and provides value to travelers. Also, during the time following the 511 designation, FHWA provided funding support to many DOTs to plan their 511 phone systems. As a result, many state DOTs and local metropolitan areas developed RCRSs during the early to mid-2000s.

More recently, in November, 2010 a final rule (23 CFR 511*) was published under the Code of Federal Regulations that establishes a real-time system management information program. The final rule defines minimum accuracy and availability requirements for public agencies to make travel condition information available regarding construction activities, road or lane blocking incidents, roadway weather observations, and travel time measurements.

Like the internet, these federal initiatives have acted as a catalyst, advancing the deployment of RCRSs and increasing the state of the practice for RCRS use.

State Perspective

From the perspective of state and metropolitan DOTs, the 511 designation provided a common 'brand' that the agencies could use to market traveler information programs. Programs such as the 511 Deployment Coalition allowed for information exchange and technology transfer, especially in the early 2000s when many states were creating their RCRSs and traveler information dissemination systems.

One trend that has occurred over the past 10-15 years has been the changing habits of travelers, as cellular phones became less expensive and more popular, the percentage of travelers with cellular phones has increased. Subsequently, many cellular phones have now been replaced by mobile devices allowing voice and data communications. Beyond the devices travelers use, the content access has changed. Additionally, social media has introduced options for further dissemination approaches. As with any industry, the expectations of travelers has increased over the years, and State and local DOTs no longer only have a traveler information phone system to manage, they now have to manage phone, web, mobile apps, social media outlets, to name a few of the current systems.

From the perspective of managing a DOT traveler information system, the use of an RCRS helps to accommodate these advances in technology. For example, the same RCRS that many states originally developed for phone and web dissemination typically now supports feeds to Twitter, Facebook, and mobile applications. Nonetheless, each DOT operating an RCRS has to manage the software development, modifications, and hosting of the RCRS. They also must manage the users who are trained to perform manual entry into the RCRS. Finally, many RCRSs are connected to automated interfaces with other systems. These also require management and updating as other systems evolve. Therefore, while RCRSs have proven to be effective and useful tools to support comprehensive traveler information systems, they require considerable management.

To understand the extent to which public agencies have modified their RCRSs, a survey question asked responders if they have made any significant changes to their RCRS since it initially launched. Twenty-one (21) responses were received to this question. Half of the respondents indicated that they have deployed a second generation RCRS and have used the same developer for both versions. Approximately one-fourth of the responders indicated that they switched to a new vendor and/or software systems since their initial RCRS launch. One state respondent (West Virginia) indicated that their RCRS is a first generation system. Overall comments received indicate that changes are needed to continually evolve and improve RCRS. Specific comments received on the history of RCRS in some states included:

- Pennsylvania DOT, which uses an in-house RCRS, implements 3 to 4 enhancements per calendar year to their system. Maryland has been adding 2 to 3 major releases to their RCRS each year since 2006.
- Oregon DOT's new RCRS version is integrated with their dispatch/incident management system. This new system avoids duplicate entry into both systems.
- The Vermont Agency of Transportation initially deployed CARS for their RCRS. In 2012 an in-house system was developed by Vermont while working with New England states on a new regional RCRS.

*Code of Federal Regulations, Title 23, Part 511 – Real-time System Management Information Program [23 CFR 511].
For more information, see: http://www.gpo.gov/fdsys/granule/CFR-2011-title23-vol1/CFR-2011-title23-vol1-part511

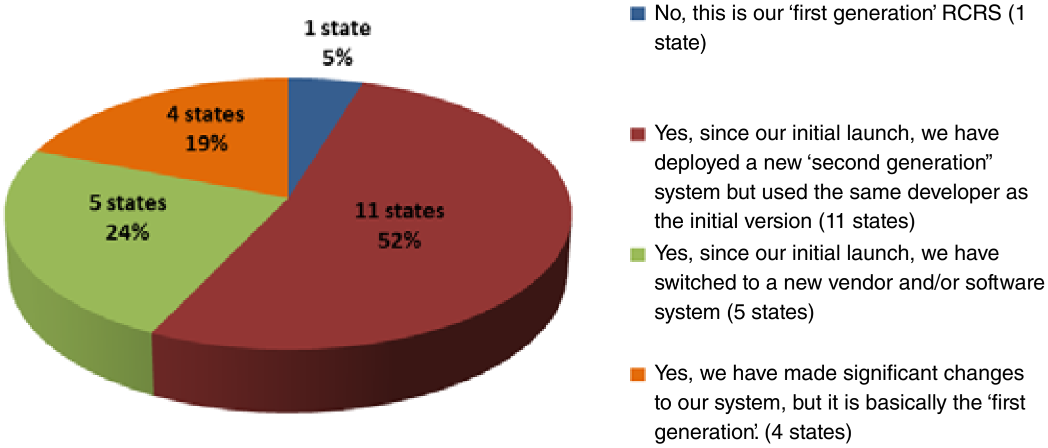


Figure 4. Responses for Question 5: Have you made any significant changes to your RCRS since you initially launched it?

The survey also asked respondents what data is currently included in their RCRS. Respondents in over nineteen states indicated that construction activities, roadway or lane blocking incidents, and road weather observations were received by their agency's RCRS. Ten respondents indicated that their RCRS received travel time information. Other data received by RCRS noted by respondents included items found in Table 1.

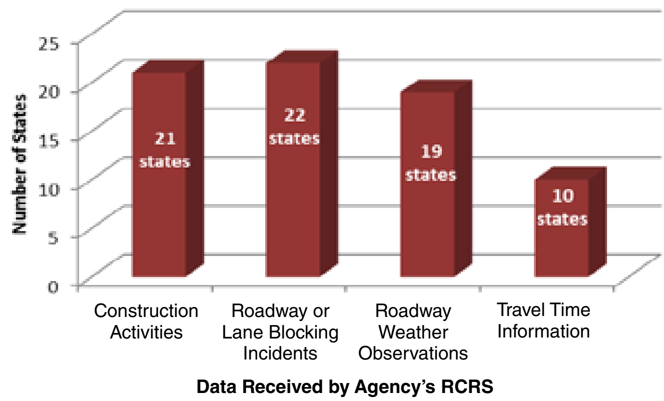


Figure 5. Responses for Question 6: What data is received by your agency's RCRS?

Table 1. Other Data Received by RCRS

Other Data/Information Received by RCRS	State
Chain Requirements	• Oregon • Nevada
CCTV	• Idaho • Nevada
DMS	• Nevada
Special Event Information	• Nevada • Oregon • Wisconsin
Road Conditions	• Montana
National Weather Service	• Idaho • Iowa
Speed Restrictions	• Montana
Weather Radar	• North Dakota
Wind speed	• North Dakota

Other Data/Information Received by RCRS	State
Maintenance Activities	• Oregon • West Virginia
Automated Vehicle Location from State Vehicles	• Maryland
Travel and Tourism	• Vermont
Load/Truck Restrictions	• Iowa • Minnesota • Montana • Oregon
Non-blocking Incidents	• Oregon
RWIS	• Maryland • Idaho
Impaired Traffic Signals	• Maryland
Point Speed Detection	• Maryland
Traffic Speeds	• Iowa

Travelers' Perspective

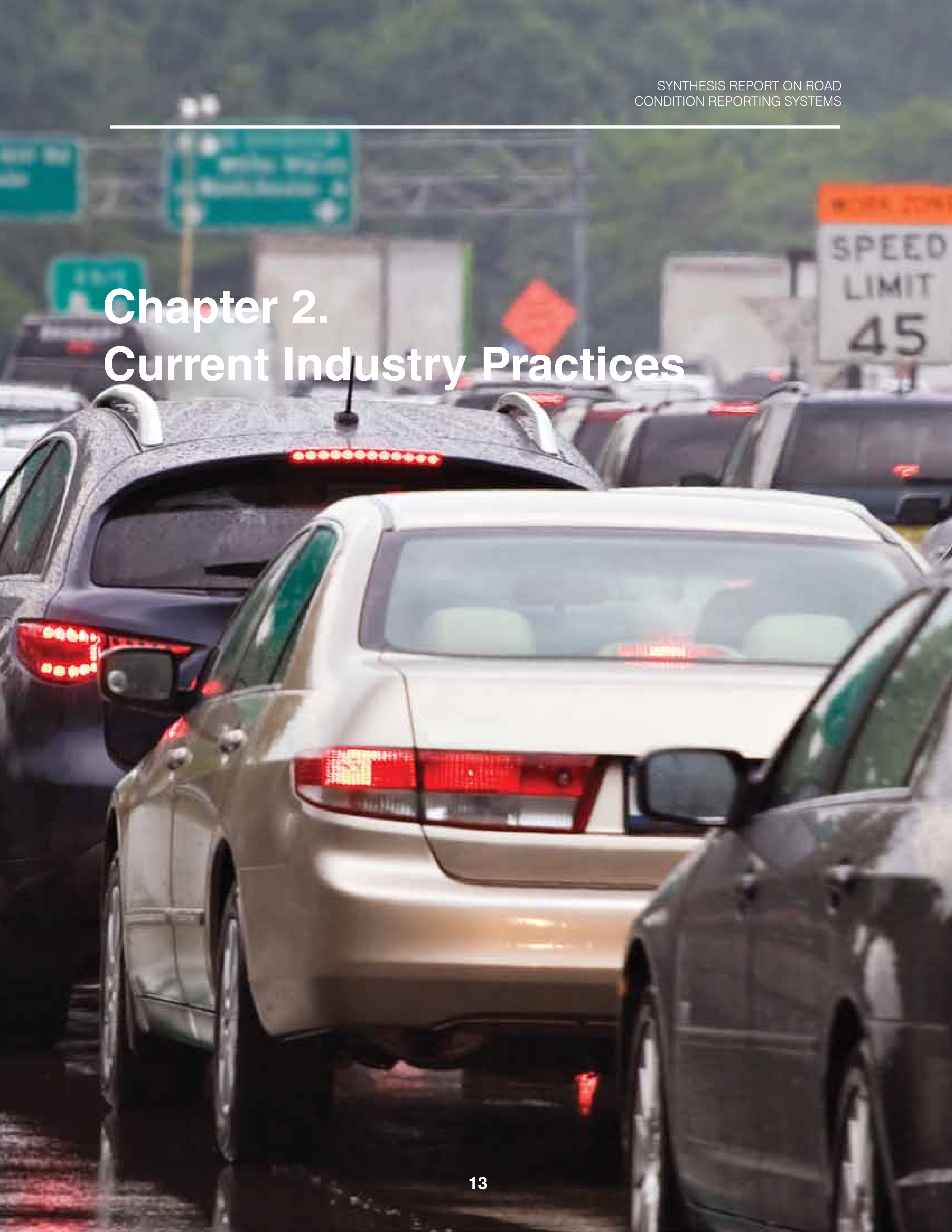
The use of mobile devices has created a world where travelers feel they can access any amount of information at any time and from any location. A combination of public private traveler information systems are often accessed from the home, vehicle, or mobile hand-held device. Not only do travelers want to access information from anywhere, but they want information to be as comprehensive as possible and not be bounded by agency boundaries.

Purpose and Organization of this Document

As a result of all the advances over the past 15-20 years and the increasing expectations of travelers, RCRSs have become critical to real-time traveler information operations within many agencies. While the potential benefits of an RCRS are obvious, there are also real costs associated with operating an RCRS. There is a wealth of information about RCRS throughout the industry. Many agencies have successfully deployed various aspects of RCRSs, and in doing so now have accumulated many lessons learned and insights that can be shared with agencies beginning a process to deploy a new RCRS or for those agencies considering expanding or enhancing an existing RCRS.

The objective of this project was to review and synthesize a compilation of current industry practices regarding the design, development, operation, maintenance, and use of an RCRS. Based on the industry practices, a further objective was to identify a smaller set of 'best practices', with proven success in delivering benefits when deployed. This document presents 49 industry practices for the design, development, maintenance, and use of RCRSs. From these industry practices, a total of 7 'best practices' are identified, and 3 'emerging best practices' describe recently introduced practices that are expected to become best practices, as the research suggests high benefits and identifies multiple agencies pursuing them. The intended use of this document is by agencies interested in understanding how other agencies have solved problems or how they manage their RCRS.

The document is structured to present practices from various perspectives. Industry practices are presented in Chapter 2. Sections of Chapter 2 present the industry practices according to the categories of traveler information define by 23 CFR 511, with additional sections to define industry practices related to transit information and other RCRS management activities. Chapter 3 presents the 'best practices', and Chapter 4 presents the 'emerging best practices'. Chapter 5 presents a summary of RCRS benefits and summarizes the benefits recognized by the use of the industry practices. This research also included a survey of transportation agencies to understand their use of RCRSs. This survey and results is included in the Appendices.



Chapter 2.
Current Industry Practices

The research conducted through this project identified a number of practices in use by the industry to enter and update data within the RCRS, and to develop, manage and maintain RCRSs. This chapter presents a set of industry practices for RCRS operations and use. The industry practices have been arranged into two categories to allow readers to better focus on their specific interests.

- Category 1: Industry practices that relate to information assembly and entry into the RCRS are presented in the first five sections. Each information assembly category section includes a brief description, applicable 23 CFR 511 requirements, general operating procedures, common challenges and agency practices.
- Category 2: Industry practices that relate to the development, management, and maintenance of the RCRS are presented afterward.

Table 2. Current Industry Practices Discussed in this Chapter

Topics		Description	Current Industry Practices
Category 1: Information Assembly and Entry	Construction/ roadwork information assembly	Agencies enter information on construction, maintenance or any DOT activities causing closures or delays.	• Semi-automated roadwork entries in Maryland • Wisconsin DOT agency-wide use of RCRS for lane closure entry and approval • Michigan DOT agency-wide roadwork entry too
	Incident/ event information assembly	Agencies enter information on incidents and planned special events that impact travel, especially those restricting traffic flow or closing lanes or roadways into RCRS.	• Minnesota DOT integration of State Patrol Computer Aided Dispatch (CAD) data into RCRS • New York Thruway Authority automated integration of CAD data • West Virginia integration of data from various law enforcement CAD systems • Wisconsin integration of incident data from law enforcement centers • Oregon DOT RCRS Combined with Dispatch and Incident Management System • Florida SunGuide RCRS Functions Combined with Road Ranger Incident Entry and Management • Washington State DOT RCRS Integration with Radio Log System • Idaho Transportation Department Shared Resources with Other State Agencies to Perform RCRS Incident and Event Entry • Oregon Local Road and Special Location RCRS
	Road weather information assembly	Road weather information reports in RCRS allows various dissemination systems to share this information in real-time with the traveling public.	• Wyoming Enhanced Citizen Assisted Reporting (ECAR) • Idaho Citizen Entry of Driving Condition into RCRS • Utah DOT – Citizen Reporting of Driving Conditions • Idaho Automated Integration of RWIS Data with the RCRS • Oregon DOT – RCRS Ingest of Weather Alerts • Maryland Automated RWIS Ingest and Integration with Manually Entered Events
	Travel time information assembly	Travel time data range from DOT calculated and supplied information to private sector products.	• New York State Thruway Authority TRANSMIT Travel Time Integration • Maryland CHART Automated Speed and Travel Time Reports • Ohio Buckeye Traffic Automated Integration of Travel Time Information • Sacramento Integration of Speed Data from PeMS • Texas DOT Integration of Travel Time Data from Various Sources
	Transit information assembly	Information dissemination describing planned departure times and real-time information reporting transit delays.	• Sacramento transit routes and bus arrival integration into RCRS • Idaho integration of transit information into RCRS

Table 2. Current Industry Practices Discussed in this Chapter (Cont.)

Topics		Description	Current Industry Practices
Category 2: Development, Management, and Maintenance	Regional integration and inter-operability	Seamless information for travelers making trips that cross jurisdictional borders and involve combinations of US, state, and local highways.	• TRANSCOM Common RCRS • Lake Michigan Interstate Gateway Alliance • Sacramento RCRS Integration of Neighboring Jurisdiction Information
	Data reliability, accuracy and timeliness	Information, particularly when manually entered, is only as timely, accurate, and useful as the data entered into the RCRS.	• Iowa DOT RCRS Training to Promote Consistent Data Entry • Oregon Automated Creation of RCRS Messages to Achieve Consistency • Washington State Streamlined RCRS Entry
	Funding and managing development and system changes	RCRS incurs costs associated with the development, management, and operations of the systems.	• Collaboration in RCRS Development, Maintenance, and Operations • Internal DOT Staff Developing RCRS Software • University Development and Support of RCRS Software • RCRS Templates Used for Local Configuration • Modularity in RCRS Design • User Group Managing RCRS Software Changes • Alaska DOT&PF Using DOT Geodatabase for RCRS • CARS Consortium Use of Location Codes
	Balancing between all that is possible and that which is practical	The potential for traveler information dissemination includes a vast number of creative mechanisms to disseminate incredible amounts of information.	• Sacramento Area Council of Governments Insight into selecting RCRS content • Idaho's Insight into selecting RSRS content • New York State Thruway Authority's Insight into selecting RCRS content • Oregon DOT's insight into selecting RCRS content

Practices for Construction / Roadwork Information Assembly

It is common that agencies enter information into their RCRS to describe construction, maintenance or any planned or unplanned DOT activities that cause road or lane closures or delays. An example would be emergency utility repairs that require the closing of one or more lanes of traffic.

Of the 22 states that replied to the survey for this project describing their RCRS, all indicated that they enter roadwork information manually or in a semi-automated fashion, as shown in Table 3 below. Since state DOTs began operating traveler information websites in the 1990s, the inclusion of current and future roadwork has always been a critical component.

Table 3. Survey Responses Describing Entry Processes for Roadwork/Construction

Data Received by RCRS	Manual Entry	Semi-Automated Entry	Fully Automated Entry
Roadwork Activities	20 states ID, IN, IA, KS, ME, MN, MS, MO, MT, NV, ND, OH, OR, PA, TN, TX, VT, WA, WV, WI	2 states CT, MA	0 states

23 CFR 511 Requirements for Construction and Roadwork Information

The parameters in the 23 CFR 511 Rule require that roadwork information is to be assembled within 20 minutes from the time of closure along Interstates outside metro areas, and within 10 minutes from the time of closure along Interstates and designated routes of significance within metro areas.

Typical Procedures for Assembling Construction and Roadwork Information

Agencies entering roadwork information into their RCRS follow a series of steps similar to the following:

Step 1: Initial entry of roadwork: The roadwork description is entered into the RCRS by a member of the construction, maintenance, planning, or operations group within the DOT. Roadwork events are often entered in advance of the start date/time, especially in situations of major roadwork or roadwork causing long term impacts. At this point the entry is typically considered a future event, and often the RCRS communicates it to the traveler information systems operated by the agency for viewing by the public as 'future events.'

Step 2: Roadwork begins: At the point in time that the roadwork begins, the event stored in the RCRS is now considered an active event. The RCRS typically shares the event description with the traveler information systems for dissemination as an 'active event.'

Step 3: Updates or details become available: As the roadwork progresses, updates may become available from the group performing the work, and if relayed to RCRS operators, they are entered as updates, changing the description of the event. These updates may include additional details about the exact location of the roadwork or details such as the number of lanes closed or the exact hours of activities impacting traffic. Also, as the project progresses, if there is an extension to the project, an updated expiration date/time for the roadwork event would ideally be entered into the RCRS.

Step 4: Completion of the event / Removal from RCRS: As the roadwork is completed, the event entered in the RCRS may either time out (i.e. the expiration date/time entered when created is reached and the event no longer exists) or be deleted by a DOT employee familiar with the roadwork activities. At this point the event will no longer exist as an active event and would be deleted from the system. There are different approaches towards storing or not storing RCRS events after the completion of the event. Some agencies cited examples of storing events to later be used in performance management reporting, while others described approaches of removing RCRS events after expiration.

Challenges Facing RCRS Information Assembly for Roadwork Events

Twenty of the twenty-two states that indicated they include roadwork in their RCRS described the entry of roadwork as a manual process (the other two indicated partially automated). The manual entry of roadwork descriptions contributes to a number of challenges facing agencies that include roadwork events in the RCRS.

Challenge #1: Lack of Detail. The RCRS description of roadwork events is only as complete as the information entered by DOT employees. At the time the roadwork is planned, there might not be extensive details available describing what lane closures will occur and when. Often, these decisions are made on-site and on a daily basis. Therefore, it is not always that the information is not entered into the RCRS; it can be that the information is not available until the crew arrives on at the site and begins work. An example of an actual roadwork event in an RCRS and displayed on a public website in February 2014 is, "The road is being reconstructed until October 31, 2014. Last updated July 15, 2013." Although this example provides correct information, it does not include the details necessary to be valuable information to the motorist.

Challenge #2: Missing Roadwork Reports. The step of manually entering roadwork events into the RCRS creates the opportunity for some roadwork events to be excluded from the RCRS. Larger events that are planned longer in the future are more likely to be included. Smaller roadwork events decided closer to the start time (e.g., pothole patching or repairs) might be more likely to be omitted from the systems. The extent of this challenge is often a factor of the structure and use of the RCRS. If an agency allows or requires multiple groups such as planning, maintenance and construction to perform direct entry into the RCRS, these groups can enter roadwork events as they are planned. If the architecture of the RCRS is such that a limited number of DOT employees perform entry, this emphasizes the need for internal communications to relay details of the roadwork to staff responsible for RCRS entry.

Challenge #3: Accuracy of Reports. The manual entry of roadwork events creates the potential for users to incorrectly describe details of the roadwork event. For example, the extent of impacts of the roadwork might not be fully understood when it is entered into the RCRS. Similarly, the start or end date of the roadwork might be entered when the event is created, but as the roadwork is performed, if the work extends beyond the scheduled date or ends early, users may neglect to change the expiration date, causing the system to incorrectly report information to the traveling public.

Industry Practices Related to Roadwork Entry into RCRS

As a result of the outreach efforts in this project, the following industry practices related to roadwork entry in the RCRS were identified.

- Industry Practice #1: Semi-automated roadwork entries in Maryland
- Industry Practice #2: Wisconsin DOT agency-wide use of RCRS for lane closure entry and approval
- Industry Practice #3: Michigan DOT agency-wide roadwork entry tool

These industry practices are summarized as follows:

Roadwork Information Assembly and Entry Industry Practice #1: Semi-automated roadwork entries for Maryland CHART

The Maryland State Highway Administration (MDSHA) has integrated their Coordinated Highways Action Response Team (CHART) RCRS[1] with the department's legacy Lane

Closure Program for semi-automated entry of roadwork alongside state roadways. The Lane Closure Program (formerly part of the agency's Emergency Operations and Reporting System – EORS) is used by MDSHA to enter permits for any work (e.g., mowing, utilities, construction) along roadways under MDSHA jurisdiction. The respective districts review and approve permits as they are requested. When the scheduled day of work arrives, contractors notify MDSHA staff to activate their permit. MDSHA staff verifies the permit and enters the roadway impacts in CHART as they were defined in the permit. The permitting process ensures that all roadwork is known before it occurs and the integration with CHART allows travelers to receive up-to-date information about potential impacts. Feedback from MDSHA described that the benefit of this industry practice is that by leveraging the comprehensiveness of the existing Lane Closure Program and then integrating that information and process with CHART ensures complete roadwork information and also has eliminated the need to teach additional staff how to operate multiple programs.

Roadwork Information Assembly and Entry Industry Practice #2: Wisconsin agency-wide use of RCRS for lane closure entry and approval

Wisconsin DOT (WisDOT) operates separate 'modular' components that function together as a comprehensive RCRS[2]. One component of the RCRS is the Wisconsin Lane Closure System (WisLCS). The WisLCS is a web-based entry tool and related database. WisLCS is not only an entry tool used by operators in the statewide Traffic Operations Center (TOC), it is also an internal business process and approval tool that is used by multiple groups within the DOT to enter planned (or unplanned) lane closures. This helps to ensure that every lane closure in the state is included in the database and XML output. As lane closures are planned for state maintained roads within Wisconsin, WisDOT staff throughout the agency use the WisLCS to enter the proposed lane closures, describing impacts, activities, dates and times of closures. The range of staff that use this tool includes the following groups: planning, construction, and maintenance. Effectively, any staff involved in planning, operating, or approving lane closures uses the tool to enter, describe, approve, or remove lane closure descriptions.

The WisLCS is more than a system to report information for dissemination to the public. It is also an internal business process and approval tool. Therefore, the proposed lane closures are entered and eventually approved in the system before they are implemented in the field. This coordinated approach whereby all groups involved in planning, approving, and executing lane closures enter the information into the WisLCS ensures that every lane closure is in the system, and available for reporting on traveler information systems.

Additional details of the lane closures may be appended to the WisLCS by operators in the statewide TOC as they receive daily or weekly updates from construction crews. Similarly, the WisLCS also allows private sector contractors to access the tool and enter updates describing current impacts of lane closure events. Updates or entries performed by outside contractors all must be approved by WisDOT supervisors before they are accepted or disseminated, but this also reduces the workload on WisDOT staff.

One example of the integrated nature of WisLCS is a theoretical bridge hit in Wisconsin. If a vehicle hit a bridge, the incident would be included in the Advanced Traffic Management System (ATMS). If this closed a lane, the lane closure (to respond to the incident) would be entered into WisLCS. If the damage to the bridge was substantial, WisDOT Maintenance would update the lane closure information to describe the long term lane closures needed to repair the bridge. Therefore, the WisLCS is a critical tool for incident response through repairing of the bridge.

Feedback from WisDOT has included the following benefits of the unique WisLCS approach:

- Thorough coverage of all lane closures in the RCRS and disseminated through traveler information systems;
- Reduced workload for TOC operators; and
- Reduced risk of incorrectly describing lane closure details when entering in another system.

Roadwork Information Assembly and Entry Industry Practice #3: Michigan DOT agency-wide roadwork entry tool

The Michigan DOT (MDOT) utilizes an in house system called Lane Closure and Restrictions (LCAR) that allow MDOT groups (i.e., construction, maintenance, operations) to enter and update road work information. MDOT reports real-time travel information on the Mi Drive website. One of the key aspects of the website is accurate reporting of road work activities on state maintained highways directly from LCAR. Construction and maintenance staff post planned construction to guide motorists in advanced route planning. MDOT operations staff along with TOC operators, edit LCAR in real-time to ensure accurate information is disseminated to the traveling public. Real-time travel information is obtained through close communication with field staff and control room operators monitoring cameras, speed sensors, and police information. In Michigan, the contractors performing maintenance work must phone in reports daily describing the anticipated impacts of the daily activities planned for the day. The operators working in any of the MDOT TOCs then use the same entry tool to update the status of road work activities. MDOT has observed a benefit of more accurate descriptions of roadwork activities using this agency-wide tool.

Practices for Incident / Event Information Assembly

Incidents include crashes, stalled vehicles, traffic stops, highway debris, and spilled loads. Special events include planned activities at entertainment venues, events causing road or lane closures, and other activities that create an increase in demand and/or decrease in capacity. Together incidents and special events create significant delay to travelers, and also are a major contributor to secondary incidents. It is common for agencies to enter information into their RCRS to describe incidents and planned special events that impact travel, especially those restricting traffic flow or closing lanes or roadways. All 22 states that responded to the project survey indicated they include roadway or lane blocking incidents in their RCRS, as illustrated in Table 4 below.

Table 4. Survey Responses Describing Entry Processes for Incidents

Data Received by RCRS	Manual Entry	Semi-Automated Entry	Fully Automated Entry
Roadway or Lane Blocking Incidents	17 states ID, IN, IA, KS, ME, MS, MO,MT, NV, ND, OH, OR, PA, TN, TX, VT, WA	3 states CT, MA, WI	2 states MN, WV

23 CFR 511 Requirements for Incident / Event Information Assembly

The parameters in the 23 CFR 511 Rule require that roadway or lane blocking incident information is to be assembled within 20 minutes from time of verification along Interstates outside the metro areas, and within 10 minutes from time of verification along Interstates and designated routes of significance within the metro areas.

Typical Procedures for Assembling Incident / Event Information

The procedures followed by the majority of agencies to enter incidents and unplanned events into the RCRS follow a series of steps similar to the following:

Step 1: Notification and verification: The discovery of incidents varies by location. Incidents occurring in metro areas equipped with a TOC and/or freeway service patrols may be observed by field staff or TOC staff monitoring camera displays or speed maps. Similarly, some agencies operate incident detection algorithms, continuously examining data to detect incidents. However, given the fact that most travelers have cellular phones, the majority of incident notifications in both urban and rural scenarios come from cellular 911 calls to law enforcement reporting the incident. Incidents are often verified through a combination of law enforcement officer verification, camera verification, or through multiple phone calls reporting the same event. For situations regarding special events, the notification varies with the event venue. However, in cases of large events, there are typically some form of notification sent to the DOT describing the likely impacts.

Step 2: RCRS incident entry: Once incidents or special events are known by the DOT or law enforcement agency, the steps to include the incident in the RCRS may vary. The primary responsibility of law enforcement is to respond to an incident, and this typically involves entry of the incident into the Computer Aided Dispatch (CAD) system. The inclusion in the RCRS requires either manual entry into the RCRS or an automated exchange of data with CAD to deliver incident reports to the RCRS. For special events, RCRS entry typically describes the impacts of the event on roads in the proximity of the event venue.

Step 3: Updates or additional details: As the incident response progresses, the RCRS entries benefit from additional details, especially estimates of clearance times for the events. Similarly, the incident described in the RCRS might differ from any entry into law enforcement CAD in that it may extend to a larger area (e.g. including the traffic backup).

Step 4: Incident clearance / Removal from RCRS: Finally, the incident needs to be cleared from the RCRS when appropriate. This is typically the decision of a TOC operator in metro areas or entry and edit staff in rural areas.

Challenges Facing RCRS Information Assembly describing Incidents / Events

Five of the twenty-two agencies that described incident entry when responding to this project's survey indicated they utilize either semi-automated or fully-automated incident entry into the RCRS. Agencies face a number of challenges to populating the RCRS with timely and accurate incident information, summarized as follows:

Challenge #1: Reporting Delays. Obviously, the earlier incidents and events are entered into the RCRS, the greater the benefits to travelers. For incidents observed by DOT staff, incident entry is only delayed by other TOC commitments. However, for incidents reported to law enforcement, there are potential challenges for the DOT to receive the information and create the appropriate events in the RCRS. Because the primary responsibility of law enforcement is incident response, manually notifying the DOT of an incident may take a lower priority.

Challenge #2: Lack of Details and Updates. For travelers, the alert that there is any type of an incident provides valuable information, regardless of the detail level. Depending upon the time of day and location of the incident, travelers can often predict the extent of expected delays (e.g., a report of any incident at 5:00 pm in a metro area will most likely result in delays). However, to truly understand impacts and determine travel pattern changes, travelers need details about the incident (e.g., direction of travel, lane closures, etc.). Finally, the most requested, and often most difficult to obtain, information is the forecasted clearance time. Assembling these details and obtaining updates as the conditions change (e.g., on-scene officers close a lane for vehicle removal) can be a challenge.

Challenge #3: Special Events Not Reported. While special event notifications will vary by event venue, one challenge that DOTs face is not receiving reliable notifications of special events. This challenge is complex because the threshold that defines when a special event is worthy of notifying a DOT is not always clearly understood (e.g., is the attendance and arrival pattern likely to cause travel delays?).

Challenge #4: Special Events Occur on Local Roads. The majority of special events occur at venues located along local roads. DOTs typically do not include local roads in the RCRS. This can present a challenge to including special events in the RCRS. A common approach is to create the event on the state maintained highways (included in the RCRS) that are most likely to be impacted by the event, however a challenge still exists to properly describe the venue to the traveling public.

Industry Practices to Address the Challenges of Incident / Events into RCRS

As a result of the outreach efforts in this project, several examples of state DOTs using approaches to overcome the challenges of incident and event entry in the RCRS were identified. A total of eight industry practices are presented, each including unique aspects of approaches to incident and event entry.

- Industry Practice #1: Minnesota DOT integration of State Patrol Computer Aided Dispatch (CAD) data into RCRS
- Industry Practice #2: New York Thruway Authority automated integration of CAD data
- Industry Practice #3: West Virginia integration of data from various law enforcement CAD systems
- Industry Practice #4: Wisconsin integration of incident data from law enforcement centers
- Industry Practice #5: Oregon DOT RCRS Combined with Dispatch and Incident Management System
- Industry Practice #6: Florida SunGuide RCRS Functions Combined with Road Ranger Incident Entry and Management
- Industry Practice #7: Washington State DOT RCRS Integration with Radio Log System
- Industry Practice #8: Idaho Transportation Department Shared Resources with Other State Agencies to Perform RCRS Incident and Event Entry
- Industry Practice #9: Oregon Local Road and Special Location RCRS

These industry practices are summarized as follows:

Incident and Event Entry Industry Practice #1: Minnesota DOT integration of State Patrol Computer Aided Dispatch (CAD) data into RCRS

The Minnesota DOT (MnDOT) reports and often responds to crashes and other incidents that block lanes on state roadways. While some crashes are detected in the Twin Cities Metro area by operators and service patrols at the MnDOT Regional Transportation Management Center, most crashes are reported by cellular 911 calls to the Minnesota State Patrol (MSP). MnDOT relies on the statewide events that are received from the MSP CAD system. MnDOT integrated their RCRS[3] with the MSP CAD system in 2010. The integration allows a CAD-generated event to appear in the RCRS and then the RCRS allows operators to take over that entry and add further details (e.g., add an event duration, change the location description of the event). The integration has worked well but there have been issues with transferring data between the two agency firewalls that have led to 5-10 minute delays in data transfers. That issue is now being resolved through CAD system updates.

Incident and Event Entry Industry Practice #2: New York Thruway Authority automated integration of CAD data

Crashes and other incidents occurring on the New York Thruway are reported to the New York State Thruway Authority (NYSTA) State Police 911 call center, where operators enter incidents into a computer aided dispatch (CAD) system. NYSTA now operates an automated interface between the 911 center CAD system and their RCRS[4] to automatically ingest incident information. As incidents are entered into the CAD system, an automated filtering process removes any sensitive information, identifies those incidents in CAD that are relevant to travel on the Thruway, and shares these incident descriptions with the NYSTA RCRS. NYSTA operators using the RCRS can review, edit, accept or reject the incident descriptions. Those accepted become active incidents in the RCRS, with the same functionality as if an operator had manually created the incident. As the incident is managed, 911 State Police operators update information about the incident. Updates are received from the CAD system. NYSTA operators view updates from the CAD system, and can determine if they wish to update the parallel event in the RCRS.

One specific detail of this industry practice is the ability of the RCRS user to edit the location of the incident that is received from the CAD system. While early designs of the system originally planned to not allow the RCRS operator to change the location of the incident, it was later determined to be critical, as often the location contained in the CAD system does not match the actual location of the event, or because the traveler information event disseminated to the public is best described by a larger area (e.g., between two major intersections) to allow drivers to detour and avoid the event.

Incident and Event Industry Practice #3: West Virginia integration of data from various law enforcement CAD systems

Crashes and other incidents occurring in West Virginia are often reported to one of the many Public Safety Answering Points (PSAPs) throughout the state. The RCRS[5] operated by West Virginia DOT (WVDOT) operates an automated ingest function to acquire incident reports from the various PSAPs' CAD systems. Traffic operators at the statewide TMC receive popup notices in real time as PSAP operators enter new and updated data on 9-1-1 calls. Incident reports to the TMC are filtered to remove any sensitive information.

Traffic operators review the 9-1-1 alerts and determine if they should be included in public facing traveler information systems. If the operator decides that the public should be notified then they can initiate a transfer to the public information system. The system will automatically generate a default traveler information message based on the information contained in the alert. The traffic operator can approve the default message, replace it, or add amplifying remarks. It is a conscious policy to force traffic operator to intervene before information is sent to the public. 9-1-1 system data is not necessarily verified or appropriate for the public, so traffic operators are required to exercise their judgment before sending information to the public. In most cases they will seek some kind of independent verification of the event before notifying the public.

West Virginia has 9-1-1 integrations in place for almost all counties which contain Interstate mileage. Plans are in place to add coverage for all remaining Interstate mileage as well as strategically chosen US primary routes.

Incident and Event Industry Practice #4: Wisconsin integration of incident data from law enforcement centers

Wisconsin State Patrol operates one overall statewide CAD system that is used to manage incidents received by State Patrol dispatchers. Additionally, Milwaukee County Sheriff's Office operates a CAD system with incidents in Milwaukee County that includes all state maintained highways and freeways in Milwaukee County. Other counties operate similar CAD systems. Wisconsin DOT (WisDOT) has developed an automated acquisition function to integrate appropriate incident reporting into the ATMS from these and a handful of other law enforcement CAD systems within Wisconsin. As incidents are entered into the CAD system, the WisTransPortal InterCAD application removes any sensitive information and filters incidents that are not of interest to WisDOT. The incident descriptions are then translated from the Global Justice XML Data Model format into the IEEE 1512 standard format. The incidents are then integrated into the ATMS software operated by WisDOT[6] as incidents. The operators in the statewide TOC then take over updating the incident. The ATMS system performs the role of the RCRS by publishing an XML feed that includes all incidents.

Incident and Event Information Entry Industry Practice #5: Oregon DOT RCRS Combined with Dispatch and Incident Management System

The Oregon Department of Transportation (ODOT) has developed one common software system that serves as the RCRS[7] and as the dispatch and incident management system used by the ODOT operators. Oregon DOT operators in the TOCs or DOT offices receive phone or radio reports from DOT staff in the field, the traveling public, and law enforcement agencies. These reports describe incidents that include:

- Animals on the roadway;
- Debris on the roadway;
- Crashes;
- Road work;
- Temporary lane closures; and
- Other reports of events or incidents.

The ODOT RCRS is the primary tool that the Transportation Operations Specialists use to enter the information they receive. Each report of a situation is entered into the system. The Transportation Operations Specialists are then responsible for managing the event, which may include dispatching maintenance staff to the scene, posting DMS messages using the TMC software, or other activities, and all of these activities are logged in the RCRS.

Because the RCRS and incident management systems are combined, ODOT operators do not need to enter the information into a separate RCRS to feed the traveler information systems.

The ODOT RCRS has internal filters and rules for determining what types of events should be shared with Information Dissemination mediums, such as the 511 website or the 511 phone system. Therefore, operators do not need to make a judgment call about what to enter into the traveler information RCRS. As an example, when an operator enters a report of an animal on the shoulder, the RCRS is used to track progress on responding to the event until it is removed, but the event would not be disseminated on the traveler information systems, whereas an entry about a tree blocking a lane would be entered in the same manner, but the RCRS filter would send that message to the traveler information systems.

Incident and Event Information Entry Industry Practice #6: Florida SunGuide RCRS Functions Combined with Road Ranger Incident Entry and Management

The Florida DOT (FDOT) road condition reporting functions are performed by Traffic Management Center (TMC)/TOC staff using a comprehensive TMC/TOC software tool called the SunGuide Software[8]. The SunGuide software is used in 12 FDOT TOCs and in several county transportation departments. Because the road condition reporting functionality is integrated as part of the overall event management, the road condition reporting is accomplished by operators as they are managing the events, rather than as a stand-alone entry of information for dissemination. The freeway service patrol (referred to as Road Rangers) use the field modules to enter reports of stalled vehicles or other incident activities. This allows timely and accurate reporting into the RCRS portion of the system, while also enabling FDOT to "grade" their Road Rangers appropriately.

The fact that all aspects of event management are performed using the SunGuide software, and activities are entered into one system provides for more comprehensive and accurate incident and event reporting than if a stand-alone RCRS were used. In addition, the details about the event management create a rich data set for performance measurement reporting. Benefits of this functionality include a rich data set capable of generating extensive performance measures, no dual entry of events/incidents into an RCRS system, and comprehensive set of incident reports.

Incident and Event Information Entry Industry Practice #7: Washington State DOT RCRS Integration with Radio Log System

The Washington State DOT (WSDOT) has an RCRS[9] that TMC staff use to enter incidents, closures, driving conditions, and other planned and unplanned events. WSDOT also operates a Radio Log System that is used by radio operators who are responsible for receiving radio and phone calls and dispatching DOT maintenance response. The two systems have separate entry tools but are integrated in that they share the same database, avoiding duplicate entry. WSDOT TMC operators use the RCRS system called ROADS to enter incidents and events. WSDOT radio room operators use a similar software tool called the "Radio Log System" to log radio exchanges and phone calls describing situations that DOT staff members respond to. The integration of the two systems prevents the need for dual entry. For example, a radio operator receiving a call from any source that there is a 'tree down' along a highway will enter this into the Radio Log System, where it will be time-stamped and saved to the database. The Radio operator can hit a button causing the event to also be part of ROADS, where TMC staff could also add details to the event description. As the radio operator dispatches crews to clear the tree and eventually enters that the event is clear in the Radio Log System, it also clears in ROADS.

One distinct advantage to the integration of both systems is the fact that not all WSDOT TMCs are staffed 24/7. In some centers, there are no TMC operators overnight, but there are always radio operators. As events are reported, the radio operators can enter them in the Radio Log System and have them move into ROADS simultaneously (feeding the traveler information systems such as 511 phone, web and Twitter). Therefore, WSDOT gets 24 hour entry of incidents and events and the radio operators do not need to use a different system from the one they are most familiar with.

WSDOT noted that the combined nature of the RCRS and Radio Log System has several benefits:

- TMC operators and radio operators can always use their own system while still entering events and incidents;
- Increased coverage of incident entry even when TMC operators are not on duty;
- Eliminate the need for dual entry of events; and
- More data available about incidents and events than if TMC operators were simply entering them for traveler information.

Incident and Event Information Entry Industry Practice #8: Idaho Transportation Department Shared Resources with Other State Agencies to Perform RCRS Incident and Event Entry

The Idaho Transportation Department (ITD) has a contract with the Idaho Department of Health and Welfare (DHW) agency, EMS Bureau to perform. entry of incidents and events into their RCRS[10]. The Emergency Medical Services (EMS) staff also performs EMS dispatch, and dispatches for a variety of other services, including Idaho Bureau of Homeland Security, Hazardous Materials (HazMat) response and Idaho Fish and Wildlife. Because this one group dispatches for such a wide variety of services, they have a vast knowledge and understanding of the conditions, events and incidents impacting Idaho. This allows for accurate and thorough descriptions of conditions and events in the Idaho RCRS and extensive coordination among agencies during major events.

The EMS Bureau performs all of the ITD dispatching statewide. Therefore, it was a logical decision to contract with this group to also perform entry into the Idaho RCRS. As a result, the EMS Bureau performs a large percentage of the event entry into the Idaho RCRS. The ITD maintenance foremen that report road driving conditions execute these reports by radioing the EMS dispatchers, who then enter the reports into the RCRS. Similarly, if there are incidents that close or impact travel lanes (e.g., a tree falling in the road), any ITD staff observing or alerted to such an event would radio the report to the EMS dispatchers. Again, while they are dispatching response crews to clear the event, they also perform an entry into the RCRS.

ITD executes a well-developed plan for training these dispatch staff. There is one EMS staff member designated as a liaison person with ITD. This is a full-time staff position enabling one person to regularly attend ITD meetings, and to fully understand the functions, reporting, dispatching, and response strategies of ITD. The liaison is then responsible for training the dispatchers to ensure the ITD procedures are followed. Based on experiences to date, ITD cited the following benefits:

- Thorough entry of driving conditions and incident reports as dispatchers have multiple sources of information;
- Reduction in ITD costs as the EMS services are contracted and effectively 'pooled' with other agencies performing dispatching and radio log entry.

Incident and Event Information Entry Industry Practice #9: Oregon Local Road and Special Location RCRS

Oregon DOT (ODOT) overcame challenges related to special events along local roads in metropolitan areas by developing a separate RCRS to be used exclusively for events on local roads, and special locations such as the vicinity to the professional basketball arena. This system provides the capability for ODOT to allow cities and counties to enter information about events along local roads. These events often include bridge openings (closing the bridge to traffic), local roadwork, and large events in the vicinity of the convention center or basketball arena. The special locations enable local communities to pre-define a geographic area that can be described by an event. The display to the traveling public (using the ODOT TripCheck website) is a shaded area, allowing travelers to understand that the event will impact all local roads in the area.

Practices for Road Weather Information Assembly

Road weather conditions is one of the most common types of information accessed by travelers through phone, web and social media services by DOTs. The dissemination of roadway conditions help travelers understand the impacts of inclement weather on their trips. Populating an RCRS with road weather information reports allows the various dissemination systems (i.e., phone, web, social media, DMS) to share this information in real-time with the traveling public. Eighteen states responding to the survey in this project indicated that road weather observations are included in their RCRS, as detailed in Table 5.

Table 5. Survey Responses Describing Entry Processes for Roadway Weather Observations

Data Received by RCRS	Manual Entry	Semi-Automated Entry	Fully Automated Entry
Roadway Weather Observations	12 states ID, IN, IA, KS, ME, MO, ND, PA, TN, TX, UT, WI	3 states MA, MI, VT	3 states OH, OR, WA

23 CFR 511 Requirements for Road Weather Information Assembly

The parameters in the 23 CFR 511 Rule require that roadway weather observations be assembled within 20 minutes from time of observation along Interstates outside the metro areas, Interstates within the metro areas, and metro area routes of significance.

Typical Procedures for Assembling Road Weather Information

The procedures followed by the majority of agencies entering road weather information into the RCRS follow a series of steps similar to the following:

Step 1: Road weather observations: Road weather reports are typically entered during the fall, winter, and spring seasons. DOTs often rely on maintenance personnel observing roadway conditions to collect the information. These observations may be performed while snow plow operators are clearing the roadway, or while maintenance supervisors are driving the roadways. In some situations, field observations are replaced by observations through camera images or from information reported by Road and Weather Information Systems (RWIS).

Step 2: Road weather report entry into RCRS: Once conditions are observed, they are reported into the RCRS. This may be performed by field staff (with mobile reporting tools) or maintenance staff using the RCRS interface. Unlike the entry of incidents, road conditions are typically reported for the same segments of highways each time (e.g. if a plow operator plows 20 miles of rural Interstate, they might enter a report describing conditions along the 20 miles).

Step 3: Updates or removal of condition reports: Assigning an estimated 'end time' to road condition reports is difficult, but is also widely sought after by travelers. Often agencies report the observation time, and then update as additional information is available. Eventually, the road report is replaced with a new report, describing a new condition.

Challenges Facing RCRS Road Weather Information Assembly

Road weather information assembly can describe information about the roadway surface (e.g., presence of snow or ice, wet pavement, etc.); sensor-recorded data describing atmospheric temperatures, wind, and precipitation; and pavement temperature sensor data, as summarized in Table 6.

Table 6. Typical Road Weather Reports from Manual or In-vehicle Observations and Typical Reports from RWIS Environmental Sensors

Manual or in-vehicle automated observations typically report	RWIS environmental sensors typically report
Pavement conditions: • Snow depth • Drifting snow • Degree that ice is covering the roadway • Status of plowing or clearing the roadway • Wet pavement • Other similar reports	Automatically measured reports: • Pavement temperature • Air temperature • Wind Speed • Precipitation type and rates

Twelve of the eighteen states that participated in the project survey indicated they include road weather observations in their RCRS described the entry of conditions as a manual process (three indicated partially automated and three indicated fully automated).

Including road condition information in the RCRS contributes to a number of challenges facing agencies, summarized as follows:

Challenge #1: Condition Observation and Data Collection. For agencies that enter driving conditions into the RCRS based on the observations made by field staff, this requires a considerable amount of time that trained staff need to spend driving the roadways and observing conditions. Often, these observations are done while operators are plowing roads, or while maintenance staff are evaluating roads to determine maintenance activities. Automated data collection by environmental sensors and related Road Weather Information Systems (RWIS) update data automatically, however the data itself is typically related to measurements taken at the site of the sensor(s) and not automatically related to roadway segments in the RCRS.

Challenge #2: Effort to Enter and Maintain Conditions. The manual step of entering roadway conditions on such a large number of road segments can present operational challenges for staff members. In addition, the activities required to maintain the roadway condition reports, updating them as conditions change or as roads are plowed or treated presents additional operational demands on staff. Similarly, the process of including weather measurements in the RCRS either relies on rules and algorithms to assign the readings from sensor locations to roadway segments, or requires manual entry of the conditions.

Industry Practices to Address the Challenges of Road Weather Information Assembly

As a result of the outreach efforts in this project, the following twelve industry practices that DOTs currently use to overcome the challenges of road weather information assembly in the RCRS were identified, and are presented in this section.

- Industry Practice #1: Wyoming Enhanced Citizen Assisted Reporting (ECAR)
- Industry Practice #2: Idaho Citizen Entry of Driving Condition into RCRS
- Industry Practice #3: Utah DOT – Citizen Reporting of Driving Conditions
- Industry Practice #4: Idaho Automated Integration of RWIS Data with the RCRS
- Industry Practice #5: Oregon DOT – RCRS Ingest of Weather Alerts
- Industry Practice #6: Maryland Automated RWIS Ingest and Integration with Manually Entered Events
- Industry Practice #7: Ohio Automated Road Condition Entries into Buckeye Traffic RCRS
- Industry Practice #8: North Dakota Automatic Ingest of Radar and Wind Speeds
- Industry Practice #9: Iowa Ingest of National Weather Service Alerts
- Industry Practice #10: Idaho Segment Entry Tool for Efficient Entry of Road Conditions
- Industry Practice #11: Utah plow operators and Meteorologist staff reporting driving conditions
- Industry Practice #12: Wyoming DOT's use of Road Condition Messaging Guidelines

These industry practices are summarized as follows:

Road Weather Information Assembly Industry Practice #1: Wyoming Enhanced Citizen Assisted Reporting (ECAR)

Wyoming DOT (WYDOT) has developed an approach for citizens to report road conditions which are then used in the department's RCRS[11]. WYDOT recognized the need to find a better way to get timely, accurate information about their roadways. They explored traditional options including increased maintenance reporting and additional roadway sensors – both of which posed a significant cost to the department. Instead, the department developed a crowdsourcing type of approach for gathering information from travelers. In 2005, the Enhanced Citizen Assisted Reporting (ECAR) feature was developed for their RCRS and by 2014 it had over 400 citizens sharing information about road conditions and any other incidents they observe on the road.

A typical ECAR volunteer is someone who drives a particular stretch of road regularly, and possibly has been doing so on a long-term basis. Many volunteers are affiliated with a transportation company or business that travels Wyoming's highways, but volunteers also include commuters and leisure travelers. ECAR participants are supplied with an illustrated handbook which includes written and visual definitions of the different types of pavement and weather conditions used by WYDOT. As an example, the difference between "slick" and "slick in spots" is described. Volunteers are also instructed on how and when to report issues such as road kill or other debris on the roadway as well as how to report incorrect information on DMS and other roadside systems.

After volunteers are trained, they interact with WYDOT operations staff to make their reports on designated routes. When they contact the department, their report consists of the following details:

- Name and access code;
- Type of vehicle being driven;
- Call back telephone number;
- Direction of travel and direction of impact;
- Route and milepost range of the event; and
- Detailed description of the witnessed event.

As a member state of the North/West Passage pooled fund program, WYDOT participated in a 2011 project to share the ECAR experience with other states and explore the feasibility of other states developing similar programs. In the final report for that project, there is a series of suggested steps for an agency to develop a citizen reporting program. Most recently, Idaho and Utah have developed programs similar to WYDOT's ECAR.

The ECAR program has been beneficial for WYDOT. The primary benefits noted are:

- Cost effective –WYDOT estimates that only $5,000 has been spent on the program to-date;
- Engages public in a positive experience with the department;
- Helps to meet the requirements in 23 CFR 511;
- Much improved consistency with internal reporting as a result of developing the external training; and
- More timely and accurate information.

Road Weather Information Assembly Industry Practice #2: Idaho Citizen Entry of Driving Condition into RCRS

In 2013, Idaho launched a function of their RCRS to enable citizens to perform entry of road condition events into the RCRS. The Idaho Transportation Department (ITD) 511 Website now includes an invitation for citizens to register to enter driving condition reports. In order to receive authority to perform condition reports, citizens must first create a personal account on the Idaho 511 Traveler Information site, and register any routes for which they intend to enter conditions. This is the same procedure citizens would perform to request alerts along routes or to personalize the 511 phone system to recognize them and play events along their routes of interest. Prior to granting reporting permissions the citizen reporters are provided training by ITD.

A web page was specially created to enable citizens to perform entry. The selection of phrases is limited, and the citizens can only select those pre-defined segments that they have registered. Idaho and Wyoming cooperated in the development of the phrases to be used for the citizen entry of events. This is to promote consistent reporting on 511 websites across the

Idaho – Wyoming borders, but also in the event that some citizens (e.g., long haul truckers) might register to perform citizen entry in both states, they could use consistent phrases.

Road Weather Information Assembly Industry Practice #3: Utah DOT – Citizen Reporting of Driving Conditions

Utah DOT (UDOT) operates a system that enables citizens to report driving conditions to help enhance the road condition information disseminated to the traveling public[12]. In order to supplement the observations made by plow operators in the field, UDOT allows recruited and trained citizens to enter observed driving conditions to populate the reporting system and ultimately reach travelers viewing the website or calling 511. UDOT has maintained a strong relationship with the Utah Trucking Association, and has invited members of this organization as well as other members of the traveling public to be volunteers to enter observed driving conditions. The overall goal is to have 800-1,000 trained citizens who are authorized to enter driving condition reports. During the first winter of operation (2013-2014, Utah trained 475 volunteer reporters who submitted a combined total of 1800 reports on 120 of the 145 segments. UDOT management has been impressed with the quality and quantity of reports to date. The reports represent a new data set that adds value to the existing data sets. UDOT has determined that the accuracy rate is over 99%, which they attribute to the reporters training program.

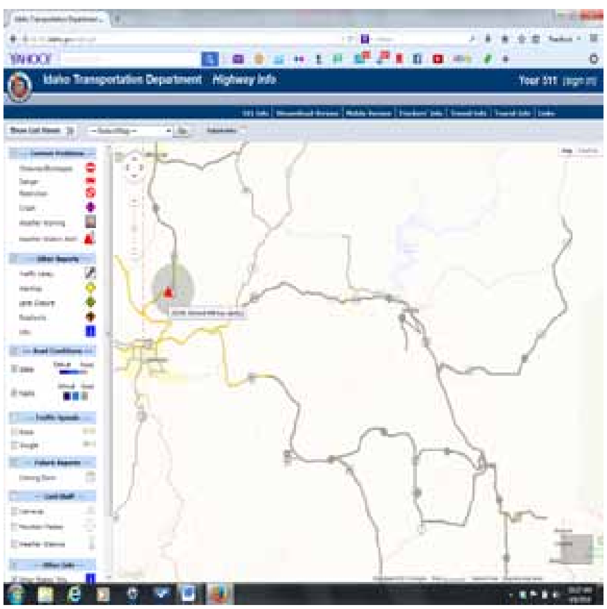
UDOT has invested considerable time in designing the citizen reporting system and how the citizen reported events will coexist with the other DOT condition reports.

- There are 145 pre-defined route segments covering the state of Utah. Regardless of the source (e.g., citizen, UDOT meteorologist, plow operator, TOC operator) road conditions are described on a per segment basis.
- Staffing levels in the statewide TOC did not allow the citizen reporting system to be structured such that citizens would telephone reports in to the TOC. Therefore, an approach was needed for citizens to report directly into a system that could manage reports and disseminate appropriate reports. UDOT created an App that citizens use from their desktop or mobile devices.
- During training, UDOT emphasizes that entry is not to be performed while driving. Also, to allow citizens who observe a condition while driving to report it when they reach their destination, the App enables them to enter a time stamp of the observation. For example, a participant driving to work might observe conditions on a segment at 7:45 am, but might not arrive at work until 8:15 am. They could enter the condition at 8:15 am and timestamp it as 7:45 am, therefore acknowledging the exact time it was observed.
- If another citizen reports a condition with a timestamp that is later than an existing report, the citizen report with the most recent timestamp of entry will replace the other report.
- Plow operators also have a mobile App for entering conditions on segments, and are the most trusted resource for entering observations. UDOT also allows consideration that entries from plow operators are the most accurate and reliable reports, given the experience and knowledge base of the plow operators. Logic is built into the system such that a plow operator reported condition cannot be overwritten by a citizen report for one hour after entered by the plow operator. This is recognition that at least for the first hour after a plow operator has entered a condition, it is the most accurate description of the conditions on the road. After an hour, conditions may have changed and a new time-stamped citizen report will replace a plow operator's report.
- Similarly, each entry has a defined time period that the condition report remains valid, if not overwritten. Plow operators' reports will remain active for 6 hours, UDOT meteorologists' entries will remain active for 4 hours, and citizen reports will remain active for 3 hours.

Road Weather Information Assembly Industry Practice #4: Idaho Automated Integration of RWIS Data with the RCRS

The Idaho Transportation Department (ITD) has developed a system to process data generated from sensors operating RWIS environmental stations in real-time and automatically create event messages in their RCRS. This practice helps to increase the number of road driving condition events in the RCRS while reducing the manual effort required to maintain the information.

The ITD RWIS Integration was an upgrade to the previous functionality to ingest and display RWIS data on the public website. Previously, the RWIS display on the public website identified the 100+ RWIS locations with icons and provided a mechanism for web visitors to click and view real-time weather information and camera images.



Source: 511.idaho.gov

Figure 6. Idaho Transportation Department RWIS Visualization

The system upgrade implemented in the fall of 2013 now operates to acquire the RWIS data and ingest it into the RCRS database where rules assign a "circle of influence" that the RWIS report is describing, and is shown in Figure 6. This circle of influence is represented as a circle on a map describing the area that is most likely described by the conditions reported. The stretch of highway that the RWIS data is assigned (and the related circle of influence) will vary based on the terrain. For example, data from RWIS stations on relatively flat straight roadways will have a larger area of influence. Data from RWIS stations in areas that are more hilly or mountainous would be assigned smaller circles of influence because conditions can change quickly as you travel a distance from the RWIS site. The ultimate plan is to automatically create events for stretches of highway based on the circle of influence assigned to each RWIS. Two types of reports are created based on the RWIS data:

- Weather events – describing inclement conditions (such as high winds, reduced visibility, snow, etc.); and
- Road condition events – describing conditions such as slick pavement, snow accumulation, etc.

Road Weather Information Assembly Industry Practice #5: Oregon DOT – RCRS Ingest of Weather Alerts

Oregon DOT (ODOT) operates an RCRS that ingests alerts (i.e., weather watches, warnings, and emergencies) from the National Weather Service (NWS). These alerts are either for county-wide areas or smaller more defined areas, as issued by the NWS. The NWS alerts are ingested exactly as issued by NWS. As the alerts are stored in the RCRS, the alerts are part of the traveler information displayed on the ODOT TripCheck website. In addition, because ODOT operators use the RCRS as their entry and management tool for entry of all events and dispatching of response, operators benefit from viewing the NWS alerts while dispatching maintenance response. The ingest of NWS watches and warnings allows ODOT staff and travelers to access NWS alerts, without any manual intervention to enter or edit weather information and content.

Road Weather Information Assembly Industry Practice #6: Maryland Automated RWIS Ingest and Integration with Manually Entered Events

The Coordinated Highways Action Response Team (CHART) RCRS[13] ingests data from the Maryland State Highway Administration (MDSHA) RWIS network to deliver high-level roadway weather information to travelers. The RWIS data is also automatically added to any incident entered into CHART to maintain a record of road conditions at the time of the event.

MDSHA has a statewide network of RWIS sites along state roadways. CHART polls the RWIS data once every minute and displays high-level roadway weather reports on the department's traveler information web site. The high-level information includes air temperature, dew point, relative humidity, wind, gust speeds, visibility, precipitation and pavement temperature. Travelers also receive additional road condition information from the manually entered shop reports when a storm is underway. The RWIS data is also automatically attached to incidents (e.g., crashes, debris) that are reported in CHART. This helps MDSHA manage real-time incident response and maintain a record of road conditions in direct correlation with an incident when it occurs. MDSHA has leveraged their initial investment in RWIS for operations, in the further delivery of that information to travelers. It also enhances the shop reports that are manually entered during storms. Attaching the road condition data to incident records also allows the department to identify patterns between incidents and weather conditions.

Road Weather Information Assembly Industry Practice #7: Ohio Automated Road Condition Entries into Buckeye Traffic RCRS

Ohio DOT (ODOT) has integrated their Road Weather Information System with their RCRS, Buckeye Traffic. The integration allows road conditions from 174 RWIS stations to be automatically fed to Buckeye Traffic every five minutes. The information is then posted to the department's traveler information web site at OHGO.com.

Buckeye Traffic ingests data from the department's network of 174 RWIS stations throughout the state. The stations are typically located along Ohio's interstate and major corridor system at 30-mile spacing and near county borders. The data from each site typically includes basic information on air and pavement temperature, pavement wet/dry status, precipitation type/intensity, and visibility. Additional information is also provided on relative humidity, dew point and wind speed/direction. Data is updated from each site every five minutes. It is then displayed on the department's traveler information web site at OHGO.com. The density and updating frequency of RWIS allows both travelers and ODOT's snow and ice staff to monitor both the onset and impact of storm activity in real-time, a valuable supplement to weather forecasts. During Ohio's snow and ice season (typically November through April), ODOT county garages and outposts throughout the state also update winter road condition approximately every two hours for their respective reporting locations. Buckeye Traffic displays the time at which the winter road condition for a particular route was last updated.

Road condition data from Buckeye Traffic is also used for the department's performance reporting on snow and ice control. The snow and ice control measure tracks hours from snow event close to normal operating speed as defined by ODOT's travel time reliability index (TTRI). TTRI is defined as the percentage of time where the baseline travel time for a highway segment was not exceeded. For example, road condition data from Buckeye Traffic is used to determine if the department meets its goal for first priority routes – regaining 10 MPH within 0-3 hours. The automated data feed from RWIS ensures that road condition information is updated frequently and consistently, particularly if updates from maintenance staff are interrupted. This consistency is important for traveler information as well as performance reporting.

Road Weather Information Assembly Industry Practice #8: North Dakota Automatic Ingest of Radar and Wind Speeds

North Dakota DOT (NDDOT) leverages two free data feeds for radar and wind speeds. The data is ingested by their RCRS[14] and used for both operations and traveler information purposes. The data allows operators and travelers to see where weather may be coming from and when it may impact North Dakota roads. NDDOT uses a free data feed from the National Weather Service XML Feeds of Current Weather Conditions to overlay wind speeds in their RCRS. The data is updated every 15 minutes. If new data is not available from the NWS feed when queried, the RCRS automatically deletes the previous data and waits for the next query. This is done as a quality check to ensure that current reports are maintained in RCRS. The wind speed data is also passed from RCRS on to the department's traveler information web site (www.dot.nd.gov/travel-info-v2/) as an information layer for travelers to view. Radar data from Iowa State University Iowa Environmental Mesonet (IEM) has also been integrated with NDDOT's RCRS to provide operations staff and travelers with a view of weather that may impact North Dakota roads. This data is updated every five minutes and it is also provided to travelers in addition to road condition reports that are manually entered by NDDOT staff. Radar and wind speeds are both presented throughout North Dakota and in the surrounding regions to maximize the ability to track weather that may be moving toward the state. Both sources for radar and wind speed data are provided free of charge for NDDOT use. The automated feeds provide a consistent and frequent source of information for operators and travelers to monitor weather that may impact travel on North Dakota roads. It is also beneficial that the data is freely provided by both sources for NDDOT use.

Road Weather Information Assembly Industry Practice #9: Iowa Ingest of National Weather Service Alerts

The Iowa DOT (IADOT) RCRS includes a module (CARS-CAP) that was designed to ingest National Weather Service watches, warnings, advisories and other similar products using the Common Alert Protocol (CAP). CAP is an XML-based information standard used to facilitate emergency information sharing and data exchange across local, state, tribal, national and non-governmental organizations of different professions that provide emergency response and management services. The use of CAP allows the Iowa RCRS to receive NWS alerts and then redistribute them to Iowa's traveler information services. For example, the data is displayed on 511ia.org under Weather Warnings for the affected counties. The weather information is displayed separately from road conditions, which are entered manually by staff throughout the state. As other emergency warnings are distributed using the CAP standard, the Iowa RCRS would be capable of receiving these as well, provided the CAP standards are adhered to. IADOT has recognized the following benefits of using the CAP standard:

- Functional system to receive NWS watches and warnings; and
- Expandability to other national, state, or local systems that may eventually share emergency information using the CAP standard.

Road Weather Information Assembly Industry Practice #10: Idaho Segment Entry Tool for Efficient Entry of Road Conditions

Idaho Transportation Department (ITD) operators receive radio reports from maintenance foremen describing driving conditions on pre-defined segments and they use an RCRS feature to quickly enter or update multiple segments. Unlike the creation of a one-time RCRS event, where the operator needs the RCRS to allow the selection of the route, the starting point, and the ending point when describing the location, the entry of driving conditions is based on radio reports from maintenance foremen who have recently plowed or observed conditions on the road. The foremen provide quick radio updates that identify the segment ID and the conditions.

The ITD RCRS includes a screen that enables operators to enter driving condition reports for segments or multiple segments quickly. Operators may select a segment, or a group of segments (e.g., if a foreman radios in that a number of segments all have the same condition) or even areas from the screen. Once selected, the operators can quickly select from limited options on drop down lists for describing the driving conditions and enter the report. Another function that the segmented entry feature performs is to aggregate data for adjacent segments when the reports are identical. In other words if a stretch of road is divided into three sequential segments (Segment 1, Segment 2, and Segment 3) and an operator selects the same conditions for Segments 1 and 3, the RCRS will create one event for the entire extent of Segments 1, 2, and 3. This helps the information dissemination tools (e.g., 511 phone and web, twitter, email) reduce the number of identical reports. Therefore, callers would hear of only one event and the location described as from the start of Segment 1 to the end of Segment 3.

This feature in the ITD RCRS has tremendously reduced the time required for operators to perform road condition entry. Since ITD uses a central call center for all the maintenance foremen to radio reports to, during winter storm they are bombarded with road condition reports. This has made the entry something they can accomplish without keeping the maintenance foremen on the line for too long. In addition, the set of standard pull-down menus for road and weather conditions produces highly consistent travel reports, with little to no variation between individual data entry personnel.

Road Weather Information Assembly Industry Practice #11: Utah plow operators and Meteorologist staff reporting driving conditions

Utah DOT (UDOT) reports both current and forecasted driving conditions for state maintained highways for up to the next 24 hours on their traveler information website. The RCRS is used to assemble all the driving condition reports that are then plotted on web-based maps as colored roadways. UDOT's approach towards reporting driving conditions allows them to report accurate road condition reports to travelers not only for current conditions but up to 24 hours into the future. In order to generate accurate and useful descriptions of the driving conditions, UDOT utilizes four approaches for assembling the road condition reports during winter seasons:

- RWIS stations. Data is returned from 80 RWIS sites throughout the state.
- Plow operators report observed conditions. Minimum reporting parameters are twice per day or as conditions change, but most often operators report multiple times per day. Plow operators use a mobile application in the vehicle to report the driving conditions as observed.
- UDOT meteorologists on staff. For several years, UDOT has employed contracted meteorologists to support the interpretation of data and observations, and generating forecasts. Between November and April, there are two meteorologists on duty in the weather room 24 hours a day, 7 days a week. During summer months, staffing is typically 10 hours per day. The on-staff meteorologists allow plow operators to communicate directly with meteorologists and to receive a 'before treatment' forecast of the impacts of winter weather to assist in planning treatment. Similarly, the meteorologists are able to understand the planned treatment and generate 'after treatment' forecasts to disseminate to the traveling public to help them understand the forecasted driving conditions for the next 24 hours. Therefore, this has been an effective method for UDOT to populate their RCRS with accurate road condition reports and forecasts.
- Citizen entry system. UDOT launched the citizen entry system, allowing citizens to enter driving condition reports, in November of 2013, and have received a large number of citizen reports describing road conditions with an accuracy of over 99%.

Beyond the benefits to the traveler information system, UDOT has recognized several benefits of the meteorologists on staff, including the dialog and discussions between plow drivers and dispatchers and the meteorologists to plan winter weather response. During summer months, the meteorologists continue to play a critical role in monitoring and managing weather situations such as flooding and forest fires, and also use the time to perform on-site maintenance of the 80 RWIS sites.

The benefits cited of the overall approach towards road condition reporting are:

- UDOT has analyzed the impacts and costs of the on-staff meteorologists and found a positive benefit to cost ratio of between 10:1 and 11:1.
- The winter tourism and ski industries benefit from UDOT's ability to keep roads open and allow visitors to reach popular destinations because of effective storm management and the traveler information provided to travelers.

Road Weather Information Assembly Industry Practice #12: Wyoming DOT's use of Road Condition Messaging Guidelines

As the Wyoming DOT (WYDOT) considered revisions to their traveler information web site, they incorporated recommendations from Guidelines for Disseminating Road Weather Advisory & Control Information developed by the FHWA Road Weather Management Program in June 2012. WYDOT overhauled www.wyoroad.info in 2012 to address newly released recommendations from FHWA for road weather messaging. The department completely rewrote the software that displays textual information on their web site to be in accordance with the messaging guidelines. The Wyoming Travel Information (WTI) system is WYDOT's RCRS. It delivers condition codes to a database and the new display software grabs the information from the database to create web pages.

Prior to making these changes, WYDOT did extensive surveying of customers to fine tune their modifications. They posted before and after examples on their web site and sought feedback through a brief online survey. The survey asked how easy it was to navigate the site, if the impact level colors were helpful, and if the "description/ recommended actions" were clear for each impact level. Final modifications were based on a combination of the recommendations from FHWA and customers. The department also created a series of Frequently Asked Questions for their web site to explain the purpose of the changes.

In addition to using the FHWA guidelines for modifying their web site, WYDOT also used them to change DMS timing, phrases and approach. The changes were made in department operating procedures and in the software that displays messages on the signs. Operators now speak of "PLA" – problem, location, action for incidents. Finally, WYDOT used a hybrid of the guidelines for DMS and web sites to develop content for a series of event center monitors. The monitors display special versions of text pages with imbedded camera images. The department has a series of monitors installed at the University of Wyoming Arena Auditorium and the Casper Event Center to provide travelers with information as they leave events. The benefits cited by Wyoming include:

- Greater consistency and clarity of information at a glance;
- Better results when recommendations were combined with customer feedback; and
- Guidelines offered a starting point for the changes WYDOT made to their web site, DMS and event center monitors.

Practices for Travel Time Information Assembly

Travel time information is beneficial to travelers planning to depart on a trip and those travelers who are currently en-route. A number of DOTs currently display travel time information on DMS, through the 511 phone system, through traveler information websites and various social media outlets. Similarly, real-time travel time data is commonly included in the in-vehicle navigation displays of vehicles. The sources of travel time data range from DOT calculated and supplied information to private sector products. Of the states responding to this project's survey, twelve indicated that they include travel time information in their RCRS as shown in Table 7.

Table 7. Survey Responses Describing Entry Processes for Data Received by RCRS

Data Received by RCRS	Manual Entry	Semi-Automated Entry	Fully Automated Entry
Travel Time Information	0 states	0 states	12 states ID, KS, MA, MI, MN, NV, OH, OR, TN, TX, WA, WI

23 CFR 511 Requirements for Travel Time Information Assembly

The parameters in the 23 CFR 511 Rule require that travel time information is to be available within 10 minutes latency along Interstates and designated routes of significance within the metro areas.

Typical Procedures for Assembling Travel Time Information

Travel time information requires automated collection or calculation of actual travel times or speed data from which travel times are derived. The following are technology approaches used today:

Vehicle readers at designated locations. Selecting pre-defined locations and equipping them with measurement devices to identify when a vehicle crosses the location for comparison with times the vehicle crossed other location detectors is a common travel time calculation. Vehicles are read using technology such as license plate readers, Bluetooth readers, or toll tag readers.

Probe vehicle data collection.
Another approach towards collecting travel time information involves the collection of data reported from participating 'probe' vehicles. These are typically vehicles for which their position is reported (e.g. using on-board GPS or cellular phone location derivation) wirelessly to a central server that consolidates the data and prepares travel times.

Speed measurement or calculation.
Finally, a common approach to travel time calculation is the measurement of speeds on individual segments (or point locations) using technologies such as radar, Doppler or loop detectors. Speeds of individual segments are added to generate corridor travel times.

Challenges Facing RCRS Travel Time Information Assembly

All twelve of the states in Table 7 above that indicated they include travel times in their RCRS described the entry of travel times as a fully automated process. The inclusion of travel times in the RCRS is too time dependent to be a manual process. Therefore, all instances involve automated integration from travel time sources to populate the RCRS.

During the research for this project, two distinct differences in approaches for including travel times were identified:

- Full integration with the RCRS – where travel times are included in the RCRS as other events or reports are included; and
- Circumventing the RCRS and displaying travel times on information dissemination systems without full integration with the RCRS.

Industry Practices to Address the Challenges of Travel Time Information Assembly

As a result of the outreach efforts in this project, the following five industry practices were identified describing approaches that agencies use to overcome the challenges of travel time information assembly in the RCRS.

- Industry Practice #1: New York State Thruway Authority Travel Time Integration
- Industry Practice #2: Maryland CHART Automated Speed and Travel Time Reports
- Industry Practice #3: Ohio Buckeye Traffic Automated Integration of Travel Time Information
- Industry Practice #4: Sacramento Integration of Speed Data from PeMS
- Industry Practice #5: Texas DOT Integration of Travel Time Data from Various Sources

These industry practices are summarized as follows:

RCRS Integration of Speed and Travel Time Industry Practice #1: New York State Thruway Authority TRANSMIT Travel Time Integration

The RCRS that the New York State Thruway Authority (NYSTA) operates includes a module that integrates travel time data from TRANSCOM's System for Managing Incidents and Traffic (TRANSMIT). TRANSMIT is a comprehensive system that includes traffic surveillance and incident detection and is based on E-ZPass electronic toll collection tags and toll readers located in multiple states. Since 1993, travelers on the New York State Thruway have had the option of electronic toll collection using the E-ZPass system. TRANSMIT aggregates all the toll tag reads to generate travel time data that is completely void of any personal information about any individual vehicles. The volume of E-ZPass equipped vehicles allows for accurate reporting of travel times.

The NYSTA RCRS includes a module (referred to as CARS-TIMES) that ingests the travel time data available from TRANSMIT. Once the travel time data is in the RCRS, the times are used to generate travel times for key segments of the Thruway. These travel times are then disseminated on DMS reporting travel to downstream landmarks, on the website, and through the Highway Advisory Radio (HAR) broadcasts. The NYSTA RCRS also includes functionality that considers the TRANSMIT travel time data and automatically generates events describing locations of slow traffic. These events describe the portion of the Thruway experiencing slower than normal traffic, and are disseminated on the website, broadcast on the HAR towers, or displayed on DMS. NYSTA cited benefits of the travel time data ingest to be:

- Increased information available to travelers through DMS, web, HAR;
- Reduced operator actions required to populate the RCRS with information about travel times and slow traffic events; and
- Increased accuracy in information disseminated.

RCRS Integration of Speed and Travel Time Industry Practice #2: Maryland CHART Automated Speed and Travel Time Reports

The Maryland State Highway Administration (MDSHA) purchases private sector data on roadway speeds to provide the basis for their Coordinated Highways Action Response Team (CHART) RCRS to develop speed and travel time reports. INRIX, a third party data provider, provides data in a link-based format for MDSHA's CHART system to assess and develop into reports about speed and travel time on state roadways. CHART also determines which DMS to active with an incident report once it is developed. The reports are also shared via the MDSHA traveler information web site. Travelers can view roadway speeds under the site's "Traffic" page and they can view DMS messages about travel time or other incident information under the site's "Info Devices" page. The information allows MDSHA to respond more efficiently to incidents and provide travelers with information that minimizes delay and the likelihood of secondary incidents. Each year, the University of Maryland conducts an independent evaluation of CHART as a program using data from the RCRS component. In their latest evaluation, the University concludes, "With respect to its performance, CHART has maintained nearly the same level of efficiency in responding to incidents and driver assistance requests in recent years. The average response time in 2012 was 9.92 minutes. In view of the worsening congestion and the increasing number of incidents in the Washington-Baltimore region, it is commendable that CHART can maintain its performance efficiency with diminishing resources. In brief, CHART operations by MDSHA in Year 2012 have yielded significant benefits by assisting drivers, and by reducing delay times and fuel consumption, as well as emissions.

RCRS Integration of Speed and Travel Time Industry Practice #3: Ohio Buckeye Traffic Automated Integration of Travel Time Information

Ohio DOT (ODOT) receives speed and travel time information from a network of sensors deployed by SpeedInfo and from INRIX. The data is integrated with their Buckeye Traffic RCRS[15] to provide travelers with automated travel time information in and between key urban areas around the state. The information is also posted to the department's traveler information web site at OHGO.com. ODOT purchases roadway data from SpeedInfo, third part data provider, and INRIX to provide travel times in and between their major urban areas throughout the state. The department prescribes the format of the data from both sources. The data is polled every minute during the day and every five minutes during the evening hours to conserve energy consumption from the roadside devices that are used to collect some of the data. Before data is transferred to Buckeye Traffic or any of the department's real-time traveler information services it is quality checked through an ODOT database where systematic quality checks are performed to identify gaps in the data. ODOT also requires both vendors to provide a confidence score on their data. The confidence score is self-reported and this was closely checked by ODOT staff in the early stages of deployment to establish confidence in the quality of the data and self-reporting process. The automation and comprehensiveness of the data available from SpeedInfo and INRIX eliminate the need for the department to operate and maintain its own infrastructure and the quality check conducted on the data ensures a consistent, reliable source of information for travelers.

RCRS Integration of Speed and Travel Time Industry Practice #4: Sacramento Integration of Speed Data from PeMS

The Sacramento Area Council of Governments (SACOG) reporting system ingests real-time speed data for freeways in the Sacramento area from the Caltrans Performance Measurement System (PeMS). In California, data is collected from over 25,000 individual detectors on freeways throughout the state. The SACOG RCRS[16] includes an automated ingest of detector data for freeways in and around the Sacramento area. The SACOG RCRS ingests speed, volume, and occupancy data for display to the operators.

The SACOG RCRS operates a function that analyzes the speed data from PeMS to automatically create events in the RCRS describing slower than normal traffic conditions. An example of an actual slow traffic event automatically created using the speed data is: US 50 westbound: between FOLSOM BLVD (Rosemont) and Exit 15: LINDEN RD (Rancho Cordova). Traffic is slow. The creation of events describing slow traffic allows SACOG to communicate conditions to travelers using multiple approaches (beyond just an Internet map displaying colored road segments). The fact that the slow traffic is described as an event on a road between two locations allows the slow traffic report to be disseminated over the 511 phone system and DMS messages, or sent to travelers using an email alert system or social media outlets. The benefits are described as follows:

- Automated creation of speed events in the reporting system allows more travelers to receive information describing travel conditions;
- Reduced workload of operators not needing to enter events describing slow speeds; and
- SACOG users of the reporting system can view traffic data to help understand the 'broader' picture of traffic conditions and formulate management plans.

RCRS Integration of Speed and Travel Time

Industry Practice #5: Texas DOT Integration of Travel Time Data from Various Sources

The Texas Department of Transportation (TxDOT) calculates travel times in metropolitan areas and these travel times are integrated into the RCRS, allowing for dissemination on various travel information systems. TxDOT fuses together multiple data sources to generate travel time reports. These data sources include loop detectors, radar, blue tooth readers, and 3rd Party data acquired through various agreements. The travel time data sources are denser in the metropolitan areas, and rural areas rely more on 3rd party data. The travel times are fused together to create travel time reports.

Practices for Transit Information Assembly

Travelers who are planning or considering transit for commute or leisure trips benefit from information dissemination describing planned departure times and real-time information reporting transit delays. It is common that transit systems are operated by a metropolitan planning organization (MPO) or a local or regional transit agency, and subsequently the information dissemination is often the responsibility of these agencies. As a result, it is not uncommon for transit information to be separate from DOT operated traveler information systems. Initiatives such as Integrated Corridor Management (ICM) that encourage real-time comparisons of freeway, arterial, and transit travel times benefit from integration of transit updates with other events impacting the road network. This project's survey did not ask questions about the inclusion of transit information in the RCRS, however the research identified industry practices related to this integration.

23 CFR 511 Requirements for Information Assembly

There are no current requirements in the 23 CFR 511 for transit information.

Industry Practices to Address the Challenges of Transit Information Assembly

One of the most prominent challenges with assembling transit information in an RCRS is that transit services are often managed by an agency other than the DOT operating the RCRS. As a result of the outreach efforts in this project, the following two examples of state DOTs integrating transit information into their RCRS were identified.

- Industry Practice #1: Sacramento transit routes and bus arrival integration into RCRS
- Industry Practice #2: Idaho integration of transit information into RCRS

These industry practices are summarized as follows:

RCRS Integration of Transit Information Industry Practice #1: Sacramento transit routes and bus arrival integration into RCRS

The Sacramento Area Council of Governments (SACOG) operates a comprehensive RCRS that supports manual and automated data entry into one central system for the use of operators managing traffic and incidents as well as dissemination to the traveling public. One aspect of the SACOG RCRS is the integration of transit routes and transit vehicle status into the RCRS.

The SACOG RCRS includes transit routes operated by local transit agencies. Transit agency staff can use the RCRS (with additional transit module) to enter descriptions of events impacting transit service. This might be a bus running behind schedule, a bus stop closed because the road is closed, or a change in service. These changes entered to the bus route to update the actual progress of buses is stored in the RCRS and output to the traveler information website. In addition, the RCRS generates a General Transit Feed Standard (GTFS) XML output that is delivered to Google Transit. This allows riders who use the Google Transit Trip Planner to receive not only static route schedule information, but also updated information based on actual conditions. Therefore, if one bus is running behind schedule and a rider were to miss a connection, the transit trip planner can describe alternate routes or transit plans. SACOG is working on the integration of automated vehicle location (AVL) data. Once integrated, this will increase the frequency of vehicle delay entry and further improve. SACOG identified the following benefits of including transit information in the RCRS:

- Increased real-time information available on the Google Transit Trip Planner in the Sacramento area; and
- Increased ability for transit operators to enter status updates to inform riders of operational status of vehicles and delay.

RCRS Integration of Transit Information Industry Practice #2: Idaho integration of transit information into RCRS

The Idaho Transportation Department (ITD) has implemented a module to their RCRS to enable transit agencies to enter their transit route information. Using this RCRS enhancement, ITD has worked with 9-10 transit systems in Idaho and in neighboring states if routes extend into Idaho. Their approach was to include as many transit providers as possible to support trips that involve connecting transit systems. ITD has included the large transit provider in Boise (operating approximately 50 buses) and small transit providers with as few as one bus.

The fact that transit routes and schedules are created inside the RCRS module allows ITD to publish the route information using the GTFS protocol, which is sent to Google for inclusion in the Google Transit Trip Planner. The RCRS inclusion of transit routes also enables the transit agencies to enter updated reports describing the transit services (e.g., delays, closed bus stops, etc.). ITD is planning to integrate AVL data from the buses, and related schedule adherence information, as a next step in expanding the functionality. ITD identified the following benefits of including transit information in the RCRS:

- Increased ability for transit operators to enter status updates to inform riders of operational status of vehicles and delay; and
- The output of schedules in GTFS has allowed data to be sent to Google. ITD is expecting the Google Transit Trip Planner to include Idaho in upcoming releases.

Practices for Regional Integration and Interoperability

Travelers regularly make trips that cross jurisdictional borders and involve combinations of US, state, and local highways. To these travelers, they rely on consistent comprehensive information. Regional integration or interoperability between neighboring jurisdiction's RCRSs contributes to travelers receiving a 'seamless' perspective of the travel conditions they will experience.

Challenges Facing Regional Integration and Interoperability

For transportation agencies, there are several challenges to assembling regional information that describes roadways operated by multiple jurisdictions. These challenges include:

Challenge #1: Nomenclature Consistency. While standards exist for phrases describing conditions on the highways, the use of these phrases is not consistent. For example, describing a roadway as "icy" as compare to "patches of ice" may be a matter of opinion or preference. To a traveler, these different uses of nomenclature could imply a change in conditions from one highway to the next.

Challenge #2: Consolidation of Data from Different Sources. There are a number of examples of metropolitan areas where commuters cross multiple state or local jurisdictions. Consolidating the data allows commuters to view a comprehensive trip report. The consolidation of data can be challenging if the systems are not able to exchange ITS standards based phrases using common protocols. These challenges may include different approaches for describing locations, different phrases to describe conditions.

Industry Practices Assisting Regional Integration and Interoperability

As a result of the outreach efforts in this project, the following three examples of DOTs achieving regional integration and interoperability of RCRSs were identified.

- Industry Practice #1: TRANSCOM Common RCRS
- Industry Practice #2: Lake Michigan Interstate Gateway Alliance
- Industry Practice #3: Sacramento RCRS Integration of Neighboring Jurisdiction Information

These industry practices are summarized as follows:

RCRS Regional Integration and Interoperability Industry Practice #1: TRANSCOM Common RCRS

The Transportation Operations Coordinating Committee (TRANSCOM) is a coalition of 16 transportation and public safety agencies in the New York – New Jersey – Connecticut metropolitan region. It was created in 1986 to provide a cooperative, coordinated approach to regional transportation management. The three state agencies all use a common RCRS system, providing economies of scale and facilitating total integration of data between the three state agencies. A key best practice of the three states using the common RCRS is that the system allows users in any TRANSCOM state to have a seamless view of incidents in all three states. The common RCRS also allows coordination of incidents across jurisdictions.

RCRS Regional Integration and Interoperability Industry Practice #2: Lake Michigan Interstate Gateway Alliance

The Lake Michigan Interstate Gateway Alliance (LMIGA) originally developed the Gateway Traveler Information System (GTIS) that ingests reports from the partner agencies, consolidates them into one overall database and displays them on the Travelmidwest website to benefit travelers throughout the Great Lakes region. Today, LMIGA and the Great Lakes Regional Transportation Operations Coalition (GLRTOC) operate the GTIS to integrate incidents, events, and construction reports from the RCRSs of participating agencies (including Minnesota, Wisconsin, Illinois, Northwest Indiana, and Michigan).

RCRS Regional Integration and Interoperability Industry Practice #3: Sacramento RCRS Integration of Neighboring Jurisdiction Information

The Sacramento Area Council of Governments (SACOG) RCRS integrates traffic, access to Closed Circuit Television (CCTV) camera images, and DMS messages from surrounding transportation agencies. This gives RCRS operators a more universal view on conditions affecting the Sacramento area. The SACOG RCRS acquires data and information describing traffic and events on surrounding roads and highways (outside SACOG control). This enables the SACOG operators to view and understand the traffic volumes and events that are on roads operated by neighboring agencies to better understand and plan for events and incidents on the SACOG operated roads. This approach benefits the operators using the RCRS and gives them a more universal view of the events and incidents impacting travelers on their highways.

Practices for Data Reliability, Accuracy, and Timeliness

While there are a number of examples of automated data collection and creation of RCRS events, a large portion of the data describing events is manually entered into the RCRS. As such, the RCRS information is only as timely, accurate, and useful as the data entered into the RCRS.

Challenges Related to Assembling Timely, Reliable, and Accurate Information

Agencies operating RCRSs face numerous challenges as they strive for timely, accurate, reliable data entry, including:

Challenge #1: Consistency. Different operators may interpret observed events or conditions differently, and/or may select different phrases to describe them.

Challenge #2: Time Constraints. Often the times that incidents occur or conditions change are busy times for TOC operators. Entry into the RCRS competes with many additional activities that operators must perform, especially if the RCRS entry process is time consuming.

Challenge #3: Operator Judgment. Often the decision about what events to enter into the RCRS or what priority to assign them is assigned to operators, and different operators might reach different decisions regarding the value of publishing events.

Industry Practices that Promote Timely, Reliable and Accurate Information Assembly

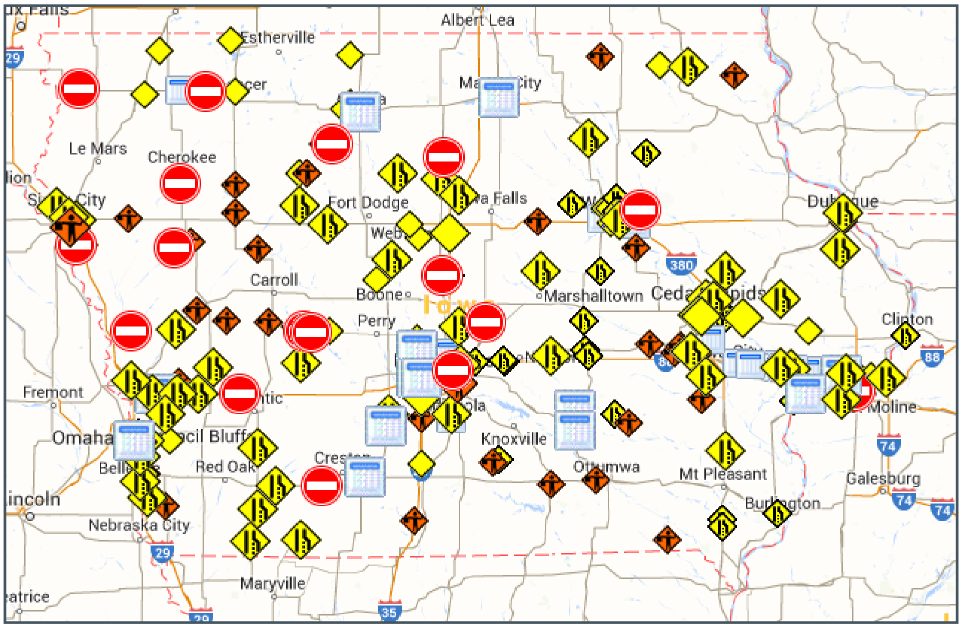
The following industry practices were identified as existing practices used to promote effective data assembly in the RCRS.

- Industry Practice #1: Iowa DOT RCRS Training to Promote Consistent Data Entry
- Industry Practice #2: Oregon Automated Creation of RCRS Messages to Achieve Consistency
- Industry Practice #3: Washington State Streamlined RCRS Entry

These industry practices are summarized as follows:

RCRS Data Reliability, Accuracy, and Timeliness Industry Practice #1: Iowa DOT RCRS Training to Promote Consistent Data Entry

The Iowa DOT (IADOT) RCRS[17] includes considerable flexibility in allowing operators to select from multiple phrases when creating an event description. The first phrase selected is the key phrase and determines the icon for display on websites, and sets the default priority. Beyond the key phrase selected, operators may also choose multiple phrases to describe an event. This is critical because the impacts vary for every event. For example, roadwork may cause no impact to travelers or it may close a lane or seriously delay travel. Using this example, operators might select two phrases to describe an event: “roadwork”, “right lane close”. With the option of being able to select the order that the phrases appear when disseminated, operators have great flexibility. However, this can contribute to inconsistencies in the way events are reported. IADOT has developed a policy that the first phrase selected should always be a description of the impact. Therefore, in this example, the operator would have ordered the phrases as follows: “Right lane closed, due to Roadwork”. Through training and a procedures manual, IADOT has achieved consistency in reporting. As a result, a quick glance at the map display on http://511ia.org displays various icons, some representing lane closures, some representing traffic slowdowns, and some roadwork. Visitors can easily understand which roadwork events are causing impacts to the travelers. Figure 7 was shared by IADOT to illustrate how web visitors can view the impacts of different events simply by observing the icons, rather than a map displaying all roadwork events using a roadwork icon, those events that cause lane closures have a lane closure icon, and those that close the road have a road closed icon.



Source: http://511ia.org

Figure 7. Iowa DOT's Illustration of How Web Visitors can View the Impacts of Different Events by Observing the Icons

RCRS Data Reliability, Accuracy, and Timeliness Industry Practice #2: Oregon Automated Creation of RCRS Messages to Achieve Consistency

The creation of the messages that are generated by the Oregon DOT (ODOT) RCRS when a user enters information is controlled by internal rules and procedures in the RCRS. Therefore, regardless of the order that users select the phrases, the RCRS will generate the message and order the phrases and information according to the design of the program. ODOT believes this helps to ensure that the reports from their RCRS are consistent regardless of the user who created the event. Similarly, since the ODOT RCRS is also the software used for radio log entry and DOT maintenance dispatch, all events communicated to one of the ODOT TOCs is entered (regardless of how much or little impact the report has). Therefore, the operator does not use their own judgment about whether or not to enter the event or to publish the event to traveler information systems. Again, internal rules and logic in the RCRS decides which events have enough impact for the RCRS to publish out to information dissemination systems and other public and private subscribers.

RCRS Data Reliability, Accuracy, and Timeliness Industry Practice #3: Washington State Streamlined RCRS Entry

The current Washington State DOT (WSDOT) RCRS has been in operation since 2008. This system replaced an earlier RCRS that had been used by WSDOT since 2000. Feedback from users who used the previous (First Generation) RCRS was that it was too complex and since they have a lot of tasks to perform in the center, they needed a simple and quick tool for entry of incidents and events. The current WSDOT RCRS is a single web page, allowing entry of all aspects of the incidents and events without the need for multiple pages. Users of the WSDOT RCRS cited the following benefits:

- Minimal training is needed on the RCRS, based on the simple design;
- WSDOT discusses the RCRS at monthly TMC managers' meetings. Because the system is simple, the focus is primarily on the need for consistency in use, and responsibilities to enter comprehensive information; and
- The simple design keeps discussions about enhancements or changes to a minimum.

Practices for Funding and Managing Development and System Changes

The use of RCRSs allows the consolidation of many types of information and supports multiple information delivery mechanisms. However, there are costs associated with the development, management, and operations of the systems.

Challenges with Funding and Managing RCRS Development and System Changes

Agencies developing or operating RCRSs face a series of challenges.

Challenge #1: Multiple Opinions. The fact that RCRSs typically have multiple users from multiple groups within the DOT creates a challenge to manage the multiple opinions on the changes needed and/or software enhancements.

Challenge #2: Internet Compatibility. The Internet has been a great catalyst in the expansion of RCRSs, and offers users the ability to access on-line RCRSs from any computer with Internet access. However a challenge this introduces is the continuously changing browser versions and/or on-line mapping options and user expectations. As a result, agencies tend to develop upgrades to their RCRSs regularly, in order to take advantage of new capabilities or to support the new browsers that users operate.

Challenge #3: Local Configurations. Users in different groups within the DOT (or geographic regions) may request local configurations to meet their specific needs that may contradict with statewide standards. Managing such requests can be challenging when budgets or software development staff time is limited.

Industry Practices that Address Funding and Managing RCRS Development and System Changes

Research in this project identified the following six industry practices that agencies use to manage RCRS development and modifications.

- Industry Practice #1: Collaboration in RCRS Development, Maintenance, and Operations
- Industry Practice #2: Internal DOT Staff Developing RCRS Software
- Industry Practice #3: University Development and Support of RCRS Software
- Industry Practice #4: RCRS Templates Used for Local Configuration
- Industry Practice #5: Modularity in RCRS Design
- Industry Practice #6: User Group Managing RCRS Software Changes
- Industry Practice #7: Alaska DOT&PF Using DOT Geodatabase for RCRS
- Industry Practice #8: CARS Consortium Use of Location Codes

These industry practices are summarized as follows:

Funding and Management for RCRS Development and System Changes Industry Practice #1: Collaboration in RCRS Development, Maintenance, and Operations

The Transportation Operations Coordinating Committee (TRANSCOM) is a coalition of 16 transportation and public safety agencies in the New York – New Jersey – Connecticut metropolitan region. It was created in 1986 to provide a cooperative, coordinated approach to regional transportation management. The three state agencies all use a common RCRS system, providing economies of scale and facilitating total integration of data between the three state agencies. A key best practice of the three states using the common RCRS is that the system allows users in any TRANSCOM state to have a seamless view of incidents in all three states. The common RCRS also allows coordination of incidents across jurisdictions. The TRANSCOM member states use the OpenReach RCRS developed by CoVal.

The Condition Acquisition and Reporting System (CARS) was initially created through a Transportation Pooled Fund that began in 1998 with a consortium of transportation agencies in North America. Member states drive the ongoing improvement and extension of CARS based on their needs and budgets. Currently, seventeen transportation agencies have deployed and are still using the CARS system, have deployed and operated the system but no long operate it, or are currently in the process of deploying the CARS system. These seventeen agencies include (or have included in the past) the City of Calgary, Idaho, Indiana, Iowa, Kentucky, Louisiana, Maine, Minnesota, New Hampshire, New York, the New

York State Thruway Authority, Rhode Island, Sacramento (through the Sacramento Area Council of Governments), Vermont, and Washington State. The members of the consortium cited the following benefits of collaboration:

- Reduced costs through the sharing of costs among active members for both development of modules and operations costs (e.g., hosting and operations);
- Sharing of lessons learned and experiences with other users;
- Sharing of training materials, training processes, and user experiences;
- Leveraging enhancements from one state across many; and
- Greater capacity and reliability in RCRS, phone and web services.

The software system that is now used in both Texas and Florida as an RCRS was originally developed by the SouthWest Research Institute (SWRI) for the Texas Department of Transportation (TxDOT). Recognizing the portability of the software, TxDOT made the software available to the Florida Department of Transportation (FDOT) at no charge. While there were no restrictions on the use of the software, FDOT contracted with SWRI to customize the software to meet FDOT's needs and also to add functionality to the software system. TxDOT has received any software additions that FDOT has added to the software. Therefore, while there is no formal consortium linking the two states, there continues to be a sharing of software development and benefits are acknowledged by both agencies.

Funding and Management for RCRS Development and System Changes Industry Practice #2: Internal DOT Staff Developing RCRS Software

All aspects of software development and hosting of the Washington State DOT (WSDOT) RCRS (ROADS) are performed in-house. WSDOT believes they have been successful in keeping software developers and IT staff because of the flexibility they offer to developers allowing them to be creative when solving problems and developing software. The advantages and disadvantages of in-house staff performing the programming described by WSDOT include:

- Tremendous flexibility and ongoing consistency – there is no need to procure services or specify exactly what software changes are needed since the staff are employed full-time;
- The flexibility and reliability allows WSDOT to focus on making the system user friendly, there is no fixed contract that requires a system be delivered a given way; and
- One noted disadvantage is that the availability of software staff to make changes does make it easier for users to request (and receive) changes that they might otherwise not request if a more formal contracting process was required with a vendor. To this extent, there are times when things in the system are changed that most likely did not need to be changed (a 'want' vs. a 'need).

In summary, WSDOT has had a good experience with in-house DOT staff developing and supporting the RCRS. They recognize they are in a somewhat unique situation, and are fortunate that their situation has resulted in some long-term employees working on software systems for the DOT for a long time.

Funding and Management for RCRS Development and System Changes Industry Practice #3: University Development and Support of RCRS Software

The modular RCRS used in Wisconsin includes one module that is a vendor supplied ATMS product and two modules that were developed by the University of Wisconsin TOPS Lab. Wisconsin DOT (WisDOT) and the University of Wisconsin-Madison TOPS Laboratory have an ongoing relationship that includes the TOPS Lab developing and supporting software used by WisDOT. The Lane Closure System (LCS) and Winter Roads System (WRS) are two modules of the RCRS developed by the University. The benefits of university development of the RCRS include:

- Potentially lower costs due to the ability to leverage state university resources (e.g., staff, facilities, etc. and the removal of fee/profit driven contracts;
- Streamlined contracting due to the ongoing relationship between the organizations;
- Flexibility in terms of contracting in that deliverables, tasks, and costs are not required to be defined in as much detail as they might be in a contract with a private sector entity with whom the DOT does not have a long term relationship; and

- Continuity that is possible because of the long term relationship between the DOT and the university.

Funding and Management for RCRS Development and System Changes Industry Practice #4: RCRS Templates Used for Local Configuration

Texas DOT (TxDOT) and FDOT have collaborated together, both contributing to the event management system that is now referred to as the SunGuide Software System in Florida and the Lonestar System in Texas. The systems perform the functions of an RCRS as well as a TMC/TOC event management software system. Several functions of the software system were developed to allow DOT administrators to configure the system to meet unique needs of the various users, without the need for software programming changes (both Florida and Texas have multiple TOCs using their respective systems). For example, the software system automatically generates recommended DMS messages in response to current conditions and incidents. This supports the operators and allows for quick consideration of all conditions when deciding which messages to post to multiple DMS. DOT operators have the capability of customizing how they want different types of events to be described on DMS. For example, operators can configure a template describing how major crashes should be described in a DMS message, and another template modification can describe how minor crashes should be defined. Another example relates to performance measure reporting. The FDOT deployment of the software system includes a comprehensive performance measure creation function. The performance measures are built using SAP® Crystal Reports. An administrator screen allows operators to create templates for the performance measure reports, and to make any changes to the configurations (either for calculations or reporting descriptions).

Funding and Management for RCRS Development and System Changes Industry Practice #5: Modularity in RCRS Design

Wisconsin DOT (WisDOT) operates separate 'modular' components that function together as a comprehensive RCRS. The RCRS comprises three separate systems, developed independently, and each operates an XML output to feed traveler information systems. The Wisconsin Lane Closure System (WisLCS) – An entry tool and related database that is used to perform entry and updates describing current and future lane closures. The Winter Roads System (WRS) – an entry tool and related database that is to enter driving condition reports. Finally, an ATMS system used to modify or enter incident information (also performs all standard ATMS functionality). Together, these three modular systems accomplish the functionality needed from an RCRS. The ATMS system is a vendor supplied system, and the WisLCS and WRS were developed by the TOPS Lab at the University of Wisconsin-Madison. Each 'module' of the WisDOT RCRS has a different set of users who primarily use the system. For example, the WisLCS is an Internal Business Process & Approval system that is used to enter and eventually approve road closures. Therefore, this is used by planning, construction, and maintenance groups, as well as Statewide TOC operators. The WRS is used by the Wisconsin State Patrol to describe driving conditions. Finally, the ATMS is used by the Statewide TOC users to manage events and traffic, controlling DMS and other field devices. Because each system is modular, each can be custom built to meet the users' unique needs, while maintaining standards-based interfaces to other systems. Collectively, all systems generate data using XML feeds that meet the reporting needs of WisDOT. The benefits of the modular design of the WisDOT RCRS are:

- Ability to focus on the unique needs of each user group; and
- Independence of one system from the next. For example the road condition reporting system was re-designed and developed new for 2013, without any change to other systems.

Funding and Management for RCRS Development and System Changes Industry Practice #6: User Group Managing RCRS Software Changes

There are six Washington State DOT (WSDOT) Regions all using the common RCRS to create reports of incidents, events, driving conditions, and roadwork on the state maintained highways. Each Region has multiple users, all with different perspectives on features and functions in the RCRS. WSDOT faced the challenge of how to manage multiple, competing requests for changes to the system.

WSDOT created an Applications User Group that consists of:

- One member from each of the six regions who uses the RCRS participates;
- One member from the WSDOT IT group that supports the software product; and
- One member from WSDOT Headquarters staff.

Collectively, the Application User Group meets monthly, just prior to the monthly TMC managers meeting to discuss requested changes from each District. The IT support member is able to offer insight regarding the amount of time and costs that would be required for changes (e.g., they may comment that one change being discussed is a simple configuration change and would require little programmer time, while another change might require a major database restructure and therefore considerably more time and resources). The WSDOT Headquarters staff is able to comment on the resources available (WSDOT has developed and supports the RCRS software using in-house software programmers with a certain amount of time dedicated to supporting the RCRS each month).

The Application User Group elects one member to chair the group (from one of the Regions represented, not the HQ staff), and they must resolve any conflicting opinions about changes. They reach decisions about how to dedicate the WSDOT software programming resources to make enhancements or changes to the RCRS. As a result of this user group, the users of the RCRS now feel like they have ownership in the system, and decision making authority.

Funding and Management for RCRS Development and System Changes Industry Practice #7: Alaska DOT&PF Using DOT Geodatabase for RCRS

The Alaska DOT and Public Facilities (AKDOT&PF) RCRS[18] defines the locations of events as either single points on the road network (e.g., a crash at an intersection) or segments of a roadway (e.g., packed snow occurring from point A to point B). A map display and a set of roadway attributes are used to allow operators to select the location of events. This can be done by either selecting the exact milepoint, an intersection, or other landmarks. The source for the features used to define the AK RCRS road network (and therefore describe events in the RCRS) is the AKDOT&PF Geodatabase. As a result, events entered in the RCRS and disseminated on the public website are displayed on high quality, accurate maps that represent the true roadway network as defined by AKDOT&PF. AKDOT&PF is currently operating an ESRI Spatial Database Engine/ Oracle Geodatabase. The Geodatabase was designed to store and manage the linear reference based centerline network and associated roadway features and attributes. The AKDOT&PF linear referenced enterprise geodatabase is built on ESRI technology using ArcGIS and ArcSDE, and uses an Oracle database. The linear reference system uses a unique CDS number (CDS_NUM field) to identify each route. Locations along a route are designated using a milepoint, or offset in miles, from the beginning of the route. Point features (such as signs and intersections) are stored in point event tables and related to a specific route with a single milepoint value (MPT field). Line features or attributes (such as guardrails or functional classification) are stored in line event tables and related a specific route with both from and to milepoint values (FROM_MPT and TO_MPT fields). The LRS design simplifies data management by automatically ensuring that a change to the centerline network (e.g., when a roadway is realigned) is reflected in the associated point and line events.

AKDOT&PF wanted to use their Geodatabase for all maps displaying incidents and events to the traveling public through the 511 Website. This was to ensure high quality maps and to avoid dependence on Internet based mapping solutions. Therefore, the RCRS and related public website are all built using the linear referenced centerline network in the Geodatabase. A regular update process is used to port changes to the AKDOT&PF road network directly to the Geodatabase used for the RCRS, thus ensuring the maps are as accurate and up to date as possible. A benefit to this is also the ability to layer event reports over the maps. For example, roadway driving conditions are layered on top of the maps created from the Geodatabase, allowing the system to color the road to reflect driving conditions with great precision.

Another benefit is the use of the Geodatabase list of consumer friendly location names. AKDOT&PF has invested time and resources identifying consumer friendly names for landmarks, and as changes are reported or new landmarks identified, these are entered directly into the Geodatabase. Because the RCRS uses this Geodatabase, there is no need to create a separate set of landmark names.

Funding and Management for RCRS Development and System Changes Industry Practice #8: CARS Consortium Use of Location Codes

The states using the RCRS developed by the CARS Consortium described the use of location codes to describe the linear attributes of the routes included in the RCRS. In some states, such as Idaho, this layer is separate from the layer used to display RCRS events using Google maps.

Events that are entered by an operator or ingested from outside systems must be assigned to geolocated attributes to support map displays or geo-referenced queries. Those member agencies using the CARS RCRS described the approach to mapping events for displays. The RCRS utilizes two different data sources for map creation:

1. The background mapping functions. These include the use of Google maps to display RCRS events on high quality, user known maps with all the zoom capabilities that Google users have come to expect.
2. An internal location code database that defines each point along the road system by latitude/longitude coordinates and any attributes of each point. The internal location code database is what enables the RCRS to provide an interface for operators to select from intersections or other known landmarks. The RCRS is also able to generate linear coloring to shade the portion of the road that is impacted by the event entered (either for display to the operator or for display to the traveling public).

The combination of the background maps and the internal location code database is able to accomplish the user needs for selecting DOT defined attributes while still benefitting from the functionality of high quality map displays.

The input for this Best Practice was received from the Idaho Transportation Department (ITD) (a member of the CARS Consortium), however the Best Practice is a benefit of the software product recognized by all members.

Practices for Balancing Possible and Practicable

The introduction and expansion of the Internet has fostered an increase in the dissemination of information. The potential for traveler information dissemination on the Internet includes a vast number of creative mechanisms to disseminate incredible amounts of information.

Challenges with Balancing Possible and Practicable

The following challenge was identified for the decision of what to include in the RCRS and related information dissemination systems.

Challenge #1: RCRS Scope. A challenge all agencies must face is the decision of what to include in the RCRS, and ultimately how to disseminate the data that is in the RCRS. The more information included, the more complex the interfaces become and the more expensive operations and enhancements are. Similarly, the RCRS users and the travelers who ultimately benefit from the system have increasing expectations.

Industry Practices for Balancing Possible and Practicable

The outreach in this project asked operators of RCRSs to describe how they consider all that is possible and ultimately decide what is practical and affordable to include in the RCRS. The following four examples were identified.

- Industry Practice #1: Sacramento Area Council of Governments Insight into selecting RCRS content
- Industry Practice #2: Idaho's Insight into selecting RSRS content
- Industry Practice #3: New York State Thruway Authority's Insight into selecting RCRS content
- Industry Practice #4: Oregon DOT's insight into selecting RCRS content

These industry practices are summarized as follows:

Balancing Possible and Practicable Industry Practice #1: Sacramento Area Council of Governments Insight into selecting RCRS content

When asked about how they maintain a balance between all the possibilities of an RCRS and consideration of information overload to travelers and available budget, Sacramento Area Council of Governments (SACOG) acknowledged that information overload of the travelers is a serious concern of theirs, but they also recognize that different travelers benefit from different information types and display types. They believe the architecture of their information dissemination systems enables them to offer various levels of information (e.g., extremely detailed information about incidents for those who seek to understand it, but also high level 'glance' summaries of the information.

One example of these multiple layers of details is found on the website. A recent event was displayed on the SACOG Traveler Information Website reporting 'slow traffic', as follows:

- At the highest level, website visitors view the icon on the map alerting them to slow traffic as shown in Figure 8.

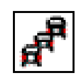


Figure 8. Example of Icon
Source: SACOG

- A user hovering the mouse over the icon receives a next level of event description, which is a brief summary of what is reported "US 50 westbound: Slow traffic."
- A user that clicks the icon would receive a detailed report of the incident "US 50 westbound: between FOLSOM BLVD (Rosemont) and Exit 15: LINDEN RD (Rancho Cordova). Traffic is slow."

This is just one example of the concept that they are able to provide a variety of information types and detail level using the design of the website to allow visitors to select what they want, and ignore the rest. For reference, the SACOG traveler information website is http://www.sacregion511.org/.

Balancing Possible and Practicable Industry Practice #2: Idaho's Insight into selecting RSRS content

The Idaho Transportation Department (ITD) commented on the topic of information overload to travelers and available budget. They noted that the department has had an adequate budget to dedicate to technology development that has allowed them to keep up with the mediums of information dissemination that travelers expect. ITD is also concerned about information overload, but feel their contractor has done a good job engineering the user interface to allow multiple approaches to traveler information, while allowing website visitors to find and focus on their specific needs. They relayed that the cooperative development of their RCRS (CARS) with other states has contributed to these well engineered user interfaces, as lessons have been learned from multiple state deployments. For reference, the ITD website is http://511.idaho.gov/.

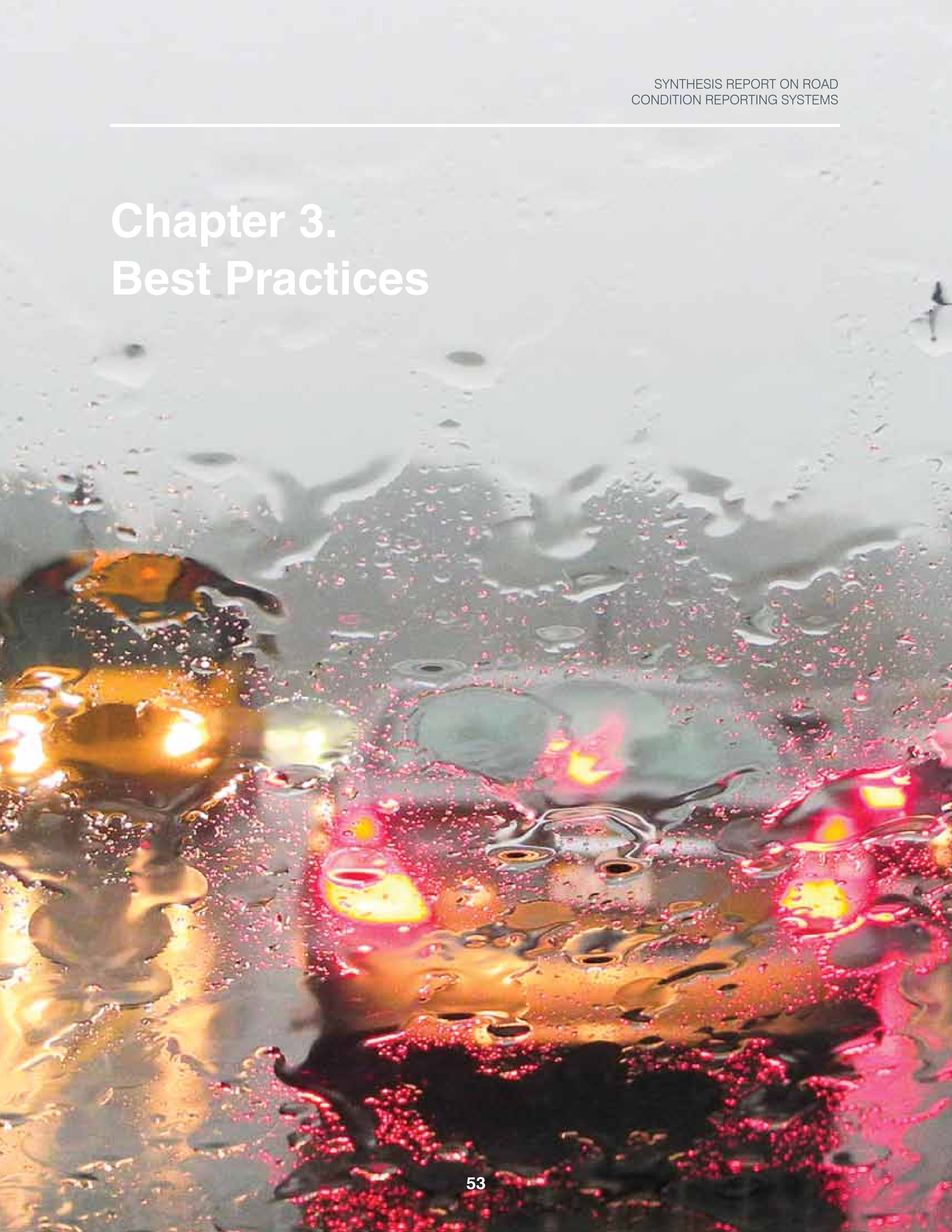
Balancing Possible and Practicable Industry Practice #3: New York State Thruway Authority's Insight into selecting RCRS content

When asked the question about the balance of all the available data and balancing information and budgets, the New York State Thruway Authority (NYSTA) responded by describing that their approach is to only include "actionable" information on their information dissemination systems. They cited the example of weather information and their decision not to include weather data from RWIS sites. They describe that if there were weather events causing alerts or advice to travelers, those would be entered as events through the RCRS, but they do not wish to overload the system with any information that is not considered 'actionable'. For reference, their traveler information website is: http://www.thruway.ny.gov/travelers/index.html.

Balancing Possible and Practicable Industry Practice #4: Oregon DOT's insight into selecting RCRS content

The representative from Oregon DOT (ODOT) described their overall approach towards avoiding information overload by noting that ODOT has never had a policy that 'more is better' in regards to information dissemination. For example, they recognize that they could show DMS locations on the public website together with the message displayed on the DMS, but they would prefer that the website visitors access information about events through the clickable icons. Therefore, they opt for a more streamlined approach to the information dissemination, rather than multiple mechanisms for displaying the same information. For reference, their traveler information website is: http://www.tripcheck.com.

Chapter 3.
Best Practices



Chapter 2 described current industry practices that agencies use in the design, management, and operations of their RCRS, together with the benefits recognized. A number of these practices have clearly demonstrated benefits to one or multiple agencies and have been selected as best practices to be further highlighted in this chapter. This chapter will describe each best practice approach listed in Table 8 and the benefits achieved by it.

The distinguishing factor between industry practices and best practices is that the best practices are those activities with the greatest benefits described or those practices that were deployed by multiple agencies, demonstrating benefits to each agency.

Several of the best practices included in this section are practices that have been implemented by multiple agencies. For these scenarios, the experiences of several agencies are presented to allow the reader to experience various details of implementation.

Table 8. Identified Best Practices Discussed in this Chapter

Identified Best Practice	Description
#1 – Automated Ingest of Law Enforcement CAD Data	An automated one-way transfer of data between the law enforcement CAD system (or systems in some states) and the RCRS. Through this transfer, a subset of the incidents in the CAD system are exported and automatically received by the RCRS. Sensitive information is removed and the event that is received by the RCRS contains only the description of what is occurring.
#2 – Combining RCRS Entry with Other Activities	Users of the RCRS are not performing entry solely for the purpose of populating the RCRS, but rather they are performing other functions, and achieving efficiencies, while improving the content of the information in the RCRS.
#3 – RCRS Ingest of Weather Data	A regular, automated ingest of weather data collected by systems external to the RCRS. Through this exchange, the regularly updated weather data is ingested on a timed cycle, and replaces the previous reports.
#4 – Integrating Lane Closure Databases into RCRS	The DOT operates a database and/or spreadsheet to track lane closures from the time that they are initially proposed and identified to result in a lane closure. This may be during early planning of roadwork to be performed in subsequent years, or it may be during the creation of emergency lane closures proposed for the following day. Creating a link between these databases and the RCRS ensures that an additional step is not required to inform TOC operators of planned lane closures.
#5 – RCRS Events Trigger of Field Device Messages	RCRS logic processes each active event against rules that determine when a message is applicable for display on one or more field devices (permanent or portable). Agencies may differ in their business rules regarding whether the RCRS generated messages are 'recommended' and must have operator approval before implementation, or if they are automatically implemented.
#6 – Generating Automated Performance Measure Data	RCRS records the time/date stamps assigned to key manual and automated actions (performed either by DOT staff or the RCRS), and store these time stamps to later generate reports. RCRSs that generate performance measure output are typically those that combine road condition and incident reporting with DOT dispatch and incident management (Best Practice #2). This is what allows for the time reports describing when responders arrive on scene and clear the incident.
#7 – Development and Operation Collaboration	Sharing at least a core portion of the RCRS software, and therefore eliminating the costs of each agency purchasing or creating the software. Collaboration can include common hosting of the RCRS (avoiding the IT hosting responsibility in each agency), or some collaborators sharing to develop additional modules or features that other members do not need, thus fulfilling their unique needs, while sharing cost savings.

Best Practice #1: Automated Ingest of Law Enforcement CAD Data

One challenge facing agencies is the timely entry of reliable incident and road closure information into the RCRS. Most incidents are now reported through cellular 9-1-1 calls to law enforcements agencies at the state or local level. Typically, when law enforcement agencies receive notices of incidents, they enter the details in their CAD system and manage the incident response. To include these event descriptions in a DOT RCRS, DOT staff need to acquire the information and manually re-enter the incident information into the RCRS.

A best practice implemented by a number of agencies to promote rapid entry of incidents into the RCRS and to minimize staff time required to enter events is the automated ingest of law enforcement CAD data into the RCRS. The concept that is common to deployments of this best practice is an automated one-way transfer of data between the law enforcement CAD system (or systems in some states) and the RCRS. Through this transfer, a subset of the incidents in the CAD system are exported and automatically received by the RCRS. Sensitive information (e.g., describing details of the crash or names of individuals) is removed and the event that is received by the RCRS contains only the description of what is occurring. This typically includes one or more phrases describing the situation, the incident location, and any additional details. Approaches differ in how the CAD incident descriptions are accepted into the RCRS, but typically there is some level of RCRS operator review before incidents become active events stored in the RCRS.

Best Practice Status: At least four documented deployments of this best practice were identified. Each deployment is beyond the proof of concept phase and accepted as a fully implemented component of the RCRS, delivering daily benefits.

Success Stories

The concept of automating the ingest of law enforcement CAD data into RCRSs was originally researched and demonstrated through a series of FHWA sponsored operational tests in Washington State[19] and Utah[20] between 2002 and 2006. Since early demonstrations, a number of agencies have created the automated ingests to deliver CAD data to RCRSs, examples of these are highlighted as follows:

In **Minnesota**, the RCRS has ingested incident reports from the State Patrol CAD system since 2010. The integration removes sensitive information from CAD-generated events and ingests them into the RCRS, allowing operators to take over further updates to the entry and add further details (e.g., add event duration, change the location description of the event). The integration has worked well but initially there were issues with transferring data between the two agency firewalls that led to 5-10 minute delays in data transfers. That issue was resolved through CAD system updates. RCRS operators may select if they wish for the incident to continue to be updated as additional CAD updates come in, or if they wish for all updates to be performed by RCRS operators.

Wisconsin DOT operates CAD to RCRS integration. In Wisconsin, law enforcement CAD to RCRS integration ingests incident reports from the Wisconsin State Patrol, the Milwaukee County Sheriff's Office, and a handful of other local law enforcement CAD systems in Wisconsin. Integrating from multiple law enforcement CAD systems introduces some additional challenges. Similar to other examples, the ingest of CAD data removes any sensitive information and filters incidents that are not of interest to WisDOT. The incident descriptions are then translated from the Global Justice XML Data Model format into the IEEE 1512 standard format. The incidents are then integrated into the ATMS software operated by WisDOT as incidents. The operators in the statewide TOC then take over updating the incidents.

New York State Thruway Authority (NYSTA) is another agency operating an automated interface between the CAD system and the RCRS. NYSTA operates the same RCRS software as MnDOT operates. Feedback from NYSTA indicated that the 9-1-1 center CAD integration has greatly reduced the need for voice communication with the State Police to understand incidents. To that extent, NYSTA estimated that 90-95% of all incidents in the RCRS come from the State Police CAD system integration. A key finding in the NYSTA system was the need for RCRS operators to be able to edit the location of the event that is received from the CAD system. The location edit feature was determined to be critical, as often the location contained in the CAD system does not match the actual location of the event, or because the traveler information event disseminated to the public is best described by a larger area (e.g., between two major intersections) to allow drivers to detour and avoid the event.

West Virginia is another state DOT operating an automated interface with 9-1-1 center CAD systems. The RCRS operated by West Virginia DOT (WVDOT) operates an automated ingest function to acquire incident reports from the various 9-1-1 call centers' CAD systems. Traffic operators at the statewide TMC receive popup notices in real time as 9-1-1 operators enter new and updated data on 9-1-1 calls. Incident reports to the TMC are filtered to remove any sensitive information. The traffic operator can approve the default message, replace it, or add amplifying remarks. It is a conscious policy to force traffic operator to intervene before information is sent to the public. 9-1-1 system data is not necessarily verified or appropriate for the public, so traffic operators are required to exercise their judgment before sending information to the public. West Virginia has 9-1-1 integrations in place for almost all counties which contain Interstate mileage. Plans are in place to add coverage for all remaining Interstate mileage as well as strategically chosen US primary routes.

Automated Ingest of Law Enforcement CAD Data – Benefits

- Increase in number of incidents reported in the RCRS
- Increased timeliness of incident reports
- Reduced workload having to manually enter incidents (as many as 95% of incidents automatically received
- Reduced verbal communications with law enforcement agencies.

Best Practice #2: Combining RCRS Entry with Other Activities

Several industry practices included in Chapter 2 describe approaches where the entry of incidents and events into the RCRS is accomplished not as a stand-alone activity, but in conjunction with other DOT or law enforcement activities. These actions "Combining RCRS entry with other activities" is identified as a best practice because a number of states actively execute this and have recognized benefits. The concept that is common to all uses of this best practice is that the users of the RCRS are not performing entry solely for the purpose of populating the RCRS, but rather they are performing other functions, and achieving efficiencies, while improving the content of the information in the RCRS. Individual agencies have achieved this best practice through a variety of approaches. In some situations, one common software solution is used as both the RCRS and the incident response and dispatch system. In other situations, the RCRS software remains a separate system, but staffing arrangements result in one group performing multiple dispatch activities in addition to RCRS entry.

Best Practice Status: At least four examples of combining RCRS entry with other activities were identified, although the approaches are all different. The deployment examples are all well embraced by the agencies operating them, suggesting that combining RCRS entry with other activities (using a variety of approaches) is an acceptable long term solution.

Success Stories

Oregon and Florida are examples where a combined RCRS/Incident management system is used by operators. In **Oregon**, the use of one common software system by TOC operators to record phone and radio reports, manage maintenance or incident response and to perform RCRS entry ensures that there is never the need to perform dual entry of incident information, and ensures that all incidents that Oregon DOT staff are responding to are included in the RCRS. For example, a phone or radio report of a tree falling and blocking a lane or road would be entered in the system, as would the actions taken to dispatch maintenance crews to remove the tree and related debris. This same entry would result in the RCRS storing an event describing the lane closure and disseminate this information to the public. Internal filters automatically determine which entries are disseminated through traveler information systems. In **Florida**, operators in the 12 TOCs use the combined TMC/RCRS software to manage incidents and report details of the incident for information dissemination. Combining the incident management and RCRS functionalities as Oregon and Florida do has the benefits of comprehensive data in the RCRS, reduced staff time performing dual entry, and allows both DOTs to generate detailed performance measure metrics for incident response.

Another example of this best practice is **Washington State DOT** integrating their RCRS with their radio log system (used to log all calls and radio communications during the dispatch of incident response) through a common database. The integration of the two systems through a common database prevents the need for dual entry. As a radio operator receives a call and enters it into the radio log, they can hit a button causing the event to also be part of the RCRS, where TMC staff could also add details to the event description. Because radio operators are staffed 24/7 and TMC staff are not always staffed 24/7, this allows RCRS entry by the radio operators at all times. Again, the benefits are more comprehensive coverage of RCRS reports and reduced dual entry.

In **Idaho**, RCRS entry is integrated with other activities through a unique staffing approach. The Idaho Transportation Department (ITD) has a contract with the Idaho Department of Health and Welfare (DHW) agency, Emergency Medical Services (EMS) Bureau to perform RCRS entry. The EMS staff members also perform medical dispatch, and dispatches for a variety of other services, including Idaho Bureau of Homeland Security, HazMat response and Idaho Fish and Wildlife. Because this one group of dispatchers performs dispatching for such a wide variety of services, they have a vast knowledge and understanding of the conditions, events, and incidents impacting Idaho. This allows for accurate and thorough descriptions of conditions and events in the Idaho RCRS and extensive coordination among agencies during major events, and avoids the need for any dual entry in multiple systems.

Combining RCRS Entry w/ Other Activities – Benefits
• More comprehensive set of incidents and events in RCRS
• Reduced need for dual entry of events
• Ability to generate detailed performance measure reports

Best Practice #3: RCRS Ingest of Weather Data

Weather measurements from environmental sensors deployed at RWIS sites provide real-time automated data describing the atmospheric and pavement conditions. However, the integration of RWIS data into an RCRS is not a trivial concept, as manual entry is a labor intensive task. A best practice implemented by a number of agencies is the automatic ingest of weather data (including RWIS data, NWS data, or other weather reports) into RCRSs. The concept that is common to all the deployments is a regular, automated ingest of weather data collected by systems external to the RCRS. Through this exchange, the regularly updated weather data is ingested on a timed cycle, and replaces the previous reports. The approaches differ in the source of the weather data. Some RCRSs ingest data from agency operated RWIS sites equipped with atmospheric and pavement sensors to record data, while others ingest NWS provided data describing conditions, watches and warnings. Another aspect of the best practice that differs by approach is how the RCRS stores the weather data. Some systems assign the weather data to a stretch of highway as an "event", another example is to use a set of rules to attach weather reports to incidents manually entered in the RCRS based on the location of the incident. Finally, some RCRSs store the weather data 'as reported' for on-screen map displays to operators and travelers.

Best Practice Status: A large number of agencies have deployed and continue to operate RCRS ingests of weather data, suggesting that this is a best practice that offers many benefits and is well accepted by RCRS operators. Similarly, RWIS sites are extensively deployed throughout the country to support a consistent use of this practice.

RCRS Ingest of Weather Data – Benefits
• More timely weather reports in the RCRS
• Reduced manual entry of weather conditions
• RCRS users can view weather information to assist in creating event descriptions
• Increased weather information disseminated to travelers

Success Stories

There is wide-scale deployment of RWIS systems, particularly in cold weather states. The RWIS data is always available to DOT agencies, and also is often disseminated to the traveling public. Similarly, there is national coverage of NWS atmospheric weather data, watches and warnings. The benefits of this best practice are achieved when DOTs create an automated ingest of the weather data into the RCRS. This project identified five state DOTs that have achieved success in creating and operating this ingest. The following real-world deployment examples describe more details of this best practice.

In **Maryland**, the CHART RCRS ingests data from the RWIS network to deliver high-level roadway weather information to travelers. In addition to ingesting the weather information, the RWIS data is also automatically added to any incident entered into CHART to maintain a record of road conditions at the time of the event. A unique aspect to the Maryland approach is that attaching weather reports to incidents allows the department to identify patterns between incidents and weather conditions.

In **Ohio**, basic air and pavement data from the 174 RWIS sites throughout the state are integrated into the Buckeye RCRS every five minutes. This ingest of RWIS data provides additional information to travelers and allows internal Ohio DOT staff to view the weather information through the RCRS, which is particularly helpful when updating the manual road weather reports.

North Dakota DOT integrates wind speed and radar data into their RCRS. The wind speeds are stored in the RCRS and passed to the department's traveler information website for display to travelers. Both the wind speeds and the radar data are visible to RCRS users to allow them to view current conditions and make decisions about weather pattern changes.

Idaho operates a module to their RCRS that ingests RWIS data and assigns a "circle of influence" to the weather reports based on rules that are mostly dictated by the terrain surrounding the RWIS site (e.g., mountainous terrain the circle of influence is smaller than flat areas). The weather reports are presented on the 511 website together with the circle of influence, allowing website visitors to understand what geographic area is most likely experiencing the conditions.

Iowa DOT operates a module in their RCRS to ingest National Weather Service watches, warnings, advisories and other similar products in the Common Alert Protocol (CAP). A unique benefit to this is that the interface that ingests the data can now be used for additional alerts published using the CAP.

Best Practice #4: Integrating Lane Closure Databases into RCRS

Disseminating planned lane and road closure information due to roadwork or other DOT activities has potentially tremendous benefits. These benefits diminish if not all the lane closing roadwork events are included, or if the reports lack details of when and where lane closures will occur. There are significant challenges to assembling a comprehensive list of roadwork activities, especially when attempting to describe specific details of closures. This project identified several examples where DOTs use an internal database to plan, authorize, and track upcoming and active roadwork related lane closures. In these examples, there is an automated link between these internal planning databases and the RCRS, creating an environment where roadwork entries in the RCRS are accurate and comprehensive. For these reasons, this was identified as a best practice. The concept that is common to all the example deployments is that the DOT operates a database and/or spreadsheet to track lane closures from the time that they are initially proposed and identified to result in a lane closure. This may be during early planning of roadwork to be performed in subsequent years, or it may be during the creation of emergency lane closures proposed for the following day. In these cases, the database is typically used to circulate notice of the lane closure and ensure that proper authorizations or permits are obtained. Creating a link between these databases and the RCRS ensures that an additional step is not required to inform TOC operators of planned lane closures.

Best Practice Status: Three deployment examples related to this best practice were identified, and the extent that other agencies follow similar practices is unknown. This best practice offers a solution to a challenge that all agencies face, however the internal planning database (and the committed use of the database by others in the agency) is critical to implementing this, therefore it is a best practice that is only suitable to agencies with these existing conditions.

Success Stories

Research and outreach conducted in this project identified three examples where an internal database tracking planned closures is integrated with the RCRS, as follows:

In **Wisconsin**, DOT staff throughout the agency use the Lane Closure System (WisLCS) to enter the proposed lane closures, describing impacts, activities, dates and times of closures. The range of staff that uses this tool includes Planning, Construction, and Maintenance. WisLCS is described as an internal business process and approval tool, as any staff involved in planning, operating, or approving lane closures uses the tool to enter, describe, approve, or remove lane closure descriptions. In addition to serving as the business process and approval tool, WisLCS acts as one module of the overall RCRS. Therefore, there is no need for TOC operators to enter lane closures into an RCRS, each closure exists in the WisLCS as a result of the business process followed to create, describe, and approve the closure.

In **Maryland**, the Lane Closure Program is used by Maryland State Highway Administration (MDSHA) to enter permits for any along roadways under MDSHA jurisdiction. The respective districts review and approve permits as they are requested. When the scheduled day of work arrives, contractors notify MDSHA staff to activate their permit. MDSHA staff verifies the permit and enters the roadway impacts in CHART as they were defined in the permit. The permitting process ensures that all roadwork is known before it occurs and the integration with CHART allows travelers to receive up-to-date information about potential impacts.

Michigan has developed and uses an agency-wide reporting tool to enter planned and active roadwork, describing every stage of the project. The planning group in Michigan DOT uses this tool when construction projects are being planned, initiating entry of events early in the planning stage. Similarly, the construction group may also create road work events or update events already created by the planning group. Similarly, as maintenance activities are planned by the maintenance group, they are entered into the same tool. This tool is used to describe planned road work through each stage of the approval and/or permitting process. The use of this one common entry tool for creating road work projects, and editing them (with edits coming from multiple groups), provides an environment where accurate descriptions about the construction and maintenance activities are available in one database, together with information about impacts that drivers can expect.

Integrating Lane Closure Databases into RCRS – Benefits
• Increased number of lane closing events in the RCRS • Reduced manual entry of roadwork • Increased details of when and where lane closures will occur

Best Practice #5: RCRS Events Trigger of Field Device Messages

The most common role performed by an RCRS is the automated supply of information to the state DOT traveler information website and phone system. However, a number of agencies also rely on their RCRS to automatically create messages to be disseminated through field devices, such as DMS and HAR. These approaches are identified as best practices as they remove or reduce the manual intervention needed from operators to disseminate information to travelers through field devices. The common aspect of all these example deployments is RCRS logic that processes each active event against rules that determine when a message is applicable for display on one or more field devices (permanent or portable). Agencies may differ in their business rules regarding whether the RCRS generated messages are 'recommended' and must have operator approval before implementation, or if they are automatically implemented. Similarly, the approach toward executing the field device messages may also differ. For systems where the RCRS has combined functionality with a TMC software, the RCRS/TMC software will communicate directly to the field device. Other situations utilize ITS standards for center to center communications where the RCRS communicates with the TMC software responsible for controlling the display of DMS or HAR messages.

Best Practice Status: At least three deployment examples were identified and other deployments are likely. For RCRSs that are combined with TMC software, this best practice is straight-forward and has a high likelihood for achieving benefits. Other RCRSs require another TMC software for the RCRS to communicate with using center-to-center standards, to support the full integration. Either way, the benefits of allowing RCRS entry and field device control without the need to access two systems are clearly recognized.

Success Stories

Research and outreach conducted in this project identified a number of examples where the RCRS triggers the recommendation of messages for field device control:

The New York State Thruway Authority (NYSTA) RCRS operates modules that consider all active incidents in the RCRS and recommends message content to be posted to one or more DMS signs and broadcast from one or more HAR stations. This RCRS functionality helps operators make decisions about what messages to post as quickly as possible, considering the location of the event, the location of the field devices, and other active events and messages disseminated on the field devices. As incidents are entered in the NYSTA RCRS (either by operators using the user interface, through the integration with the CAD-9-1-1 interface, or through the TRANSMIT integration), the system automatically processes a set of rules and generates recommended messages for either permanent or portable DMS signs upstream of the incident(s). A similar set of rules also recommends messages for broadcast on the HAR towers. Operators using the RCRS are able to view recommended messages, and may either confirm the message or edit the message before posting, or ignore the message suggestion. The **NYSTA** operators use the RCRS to manually enter messages to be displayed on portable or permanent DMS. Therefore, the RCRS maintains information describing the current messages displayed on each sign. This allows 'rules' or algorithms to consider whether other existing messages (e.g., messages manually entered by users for display on the sign) are higher in priority to messages that might be generated to describe incidents on the Thruway.

The control of HAR towers is similar, with **NYSTA** staff using the RCRS to define content to be played on the HAR stations. Logic in the RCRS considers the current play list for each HAR tower and identifies recommended messages to be broadcast on the HAR towers. As events in the RCRS expire or are cancelled by operators, the same logic automatically clears DMS message displays or HAR tower broadcasts describing the event. NYSTA staff worked with the contractor to develop the logic that determines the messages that are recommended for both DMS and HAR. Travel times are a common message displayed on DMS and broadcast over HAR, especially during peak periods.

The **Florida** SunGuide Software System has the ability to automatically recommend messages to be posted on DMS based on current events and conditions. The SunGuide System operates with a message template editor that enables DOT operators to customize how they want different types of events to be described on DMS. For example, FDOT can configure a template describing how major crashes should be described in a DMS message, and another template modification can describe how minor crashes should be defined.

In **Iowa,** HAR and Low Power FM broadcasts are used to disseminate traveler information through AM and FM radio broadcasts. The playlists and content are determined by the RCRS, using a set of rules similar to those described above.

Benefits of the deployments of this best practice include

- Quicker posting of messages to DMS and HAR, and therefore better informed travelers;
- Support to operators to consider all incidents and all DMS when determining a response; and
- Reduced staff time that would otherwise be spent entering messages for field device display.

RCRS Events Trigger of Field Device Messages – Benefits
• Reduced manual creation of DMS and HAR content
• Reduced time to display incident and event information on DMS and HAR
• Consideration of the broad picture of events when selecting messages

Best Practice #6: Generating Automated Performance Measure Data

Many state and local DOTs now identify performance targets, and use performance measures to decide how to invest resources in projects that will achieve these targets. A key aspect of Map-21 is the establishment of a performance and outcome based program. Several states now use their RCRS to generate the data to support performance measurements. The concept that is common to the best practice deployment examples is that the RCRSs record the time/date stamps assigned to key manual and automated actions (performed either by DOT staff or the RCRS), and store these time stamps to later generate reports. These time stamps create a timeline for incident response that typically includes:

- Time the incident is reported;
- Time the incident is available on 511 phone, web and social media outlets;
- Time that DOT or law enforcement responders arrive on scene;
- Time that the scene is cleared;
- Time that any reports of traffic delay or lane closures are cleared; and
- Any times that condition reports change (e.g., entering a lane or road closure for limited periods during response).

A unique aspect of this best practice is that the RCRSs that generate performance measure output are typically those that combine road condition and incident reporting with DOT dispatch and incident management (see Best Practice #2). This is what allows for the time reports describing when responders arrive on scene and clear the incident.

Best Practice Status: At least three deployment examples were identified and the agencies have used the RCRS for performance reporting for multiple years. The benefits are high and the risks are low for this deployment. It is suitable to agencies that enter enough data into the RCRS to generate the performance measures needed.

Success Stories

Three examples of this best practice were identified. In each example, the agencies have come to rely on the output of the RCRS to generate performance measurements.

The **Oregon** RCRS performance measure reports allow Oregon DOT to track such things as the percentage of incidents disseminated to the traveling public within 10 minutes of notification. In addition, the report includes a graph displaying the monthly average delay in notifying the public of incidents and condition changes. The integration of the Oregon DOT RCRS with the actual system used to manage incidents makes the performance reporting possible. It creates a set of data about milestones such as:

New Jersey DOT has been generating monthly performance reports for the Federal Highway Administration's division office since 2006. The reports present information about incident management performance and they are generated using data from the agency's RCRS. In 2008, New Jersey DOT and FHWA worked together to identify a set of performance measures that could be reported on a monthly basis. The following performance information is included in the monthly report to FHWA:

- Number of incidents;
- Average incident duration;
- Number of incidents > 90 minutes in duration and number of incidents < 90 minutes in duration;
- Incidents during peak/non-peak;
- Total incidents on freeways/arterials;
- Incidents involving fatalities; and
- Incidents involving Incident Management Response Team (IMRT).

The reports further break down the information by incident type (e.g., crash, emergency roadwork, debris on roadway) and by roadway. This information is not only reviewed by FHWA, it is also used by the New Jersey DOT as a resource in their congestion relief program.

The reports are specified by New Jersey DOT and programmed to be automatically generated by the RCRS.

Because the **Florida** RCRS functionality is integrated as part of the overall event management, the result is a 'rich' data set of information describing all aspects of each event. The RCRS is capable of automatically generating performance measurement reports that describe individual event details, weekly, monthly, quarterly, or annual measures. Some example outputs that can automatically be generated by the system include:

- Notification Duration – the number of minutes between the time FDOT or FHP are notified and the TMC/TOC is notified;
- Verification Duration – the number of minutes between the time the FDOT TMC/TOC is notified and the TMC/TOC verifies the event;
- Response Duration – the number of minutes between the TMC/TOC verifying the event and first responder arriving on the scene;
- Open Roads Duration – the number of minutes between the first responder arriving and the travel lanes being cleared;
- Roadway Clearance Duration – the number of minutes between the initial FDOT or FHP notification and the travel lanes being cleared; and
- Incident Clearance Duration – the number of minutes between the FDOT or FHP notification time and the time the last responder departs from the incident.

RCRS Generates Automated Performance Measure Data – Benefits
• Increased performance management data
• Reduced staff time tracking performance metrics
• Better understanding of the impacts of traveler information

Best Practice #7: Development and Operation Collaboration

The costs of developing and maintaining an RCRS can be significant. Beyond the costs related solely to the software, there are costs related to the planning and design of the system (including costs to continuously monitor the changing landscape of Internet browsers and functionality supported), the costs of training, and training materials and other documentation. There are several examples of agencies that have collaborated together to develop, maintain, and continue to enhance one common RCRS. A common aspect of agencies collaborating in the development of the RCRS is the sharing of at least a core portion of the RCRS software, and therefore eliminating the costs of each agency purchasing or creating the software. Beyond this commonality, there are examples where collaboration includes common hosting of the RCRS (avoiding the IT hosting responsibility in each agency). There are also examples where some members sharing in the collaboration develop additional modules or features that other members do not need. Therefore, these agencies accomplish their unique needs, while still sharing in the cost savings.

Best Practice Status: There are examples of agencies collaborating in RCRS development for more than 15 years. This is a proven success story for those agencies that can accept the compromises of collaborative development in exchange for the benefits that come with it.

Success Stories

One example of RCRS collaboration is TRANSCOM, where three states (New York, New Jersey, and Connecticut) use a common RCRS, allowing operators in each state to see incidents across jurisdictions. This common RCRS works as the agencies are adjacent to each other and one central system provides seamless integration of incidents.

Another example is the CARS Consortium, where a group of agencies collaborate in the development, operations, and hosting of the RCRS software, but individual software applications are operated for each agency. Consortium members cited the sharing of development costs, the sharing of training and user materials, and the sharing of lessons learned as key benefits of this type of collaboration.

Another example of shared source code deployed in different locations is the Florida and Texas collaboration on the SunGuide / LoneStar systems. Similar benefits were cited, including shared development costs, experience sharing, and collaboration among users.

The nature of RCRSs is such that similar functions are performed by nearly every agency that operates an RCRS. Therefore, the opportunities for collaboration, cost sharing, and technology transfer are tremendous. Collaborating with other agencies is not suited to all organizations. Collaboration implies some compromise between partnering agencies, but the individuals sharing their experiences on this best practices relayed a feeling that the benefits outweighed the drawbacks.

Collaboration In Development and Operation of RCRS – Benefits
• Cost sharing with partner agencies • Sharing lessons learned, training material, and other resources • Opportunities for economies of scale and increased capacity when hosted together

Chapter 4.
Emerging Best Practices

This chapter presents a number of industry practices that have been identified as 'emerging best practices', which are listed in Table 9. These are practices likely to become best practices as the research suggests high benefits and multiple agencies are pursuing them. However, these practices have only recently been developed and deployed and are still too new to classify as a best practice.

Although these practices are identified as emerging, several of the practices have been deployed by multiple agencies. For these scenarios, the experiences of several agencies are presented.

Table 9. Identified Emerging Best Practices Discussed in this Chapter

Identified Emerging Best Practice	Description
#1 – Citizen Reporting into RCRS	Agencies have developed their systems to allow citizens to report weather and driving conditions into the RCRS. This reporting approach empowers citizens that drive the roads every day with the ability to report their observations, effectively increasing the number of observations from a small number of DOT staff to any number of citizens who may be driving the road.
#2 – Integrating Transit Data into the RCRS	Reporting transit into the RCRS allows the system to ingest updates describing the status of buses (either collected automatically or manually entered) so that delayed buses can be treated as events in the RCRS and information describing the delays can be provided to travelers using the dissemination mechanisms tied to the RCRS.
#3 – Integration of Third Party Data	Data that is purchased from a private sector vendor or received from other public entities (e.g., a public toll facility) is viewed by some as an alternative to deploying additional publicly owned infrastructure that requires ongoing maintenance. This includes automated (no human intervention) ingest of data combined with logic to assign the data to the corresponding segments of road.

Emerging Best Practice #1: Citizen Reporting into RCRS

As described earlier in this report, timely and accurate weather and driving condition reporting into the RCRS is critical for a successful traveler information system. A best practice was described for ingesting weather data into the RCRS from various weather monitoring systems. In addition to this, in recent years a number of agencies have developed their systems to allow citizens to report weather and driving conditions into the RCRS. The idea of this reporting approach is to empower the citizens that are driving the roads every day with the ability to report their observations. This effectively increases the number of observations from a small number of DOT staff to any number of citizens who may be driving the road. The elements that are common to all citizen reporting systems are:

- Training. Each agency that has deployed citizen reporting thus far performs some level of training with the citizens before they are authorized to report;
- Common reporting criteria. In order to ensure consistency with how citizens report conditions (e.g., snow-packed, scattered icy spots, etc.) common criteria are explained during training;
- Reporting after driving. Citizens are instructed not to enter while on the road, but rather after they have arrived at their destination;
- Operator review. Citizen reports typically are reviewed before publishing to traveler information systems; and
- Monitoring. Citizen reports are evaluated regularly to ensure accuracy (and to potentially identify and remove any citizens from the program performing inaccurate reports).

Emerging Best Practice Status: There are three documented deployments of citizen reporting systems, two of which began operation during the 2013/2014 winter season. While all are currently considered successful, this is a practice that relies on voluntary citizen involvement and as such the long-term success will be dependent upon retaining the participation of volunteers.

Success Stories

The first agency to formally introduce a citizen reporting system was Wyoming DOT. Wyoming has openly shared resources such as training materials and recruitment tools. A project performed by the North/West Passage Pooled Fund helped share Wyoming lessons learned with other states. Idaho and Utah have since deployed similar citizen reporting systems, and collaboration between all three states has helped to standardize the phrases used. Standardization of phrases could make it easier for citizens (such as long-haul truckers) to be trained and enter data in multiple states.

Citizen Reporting into RCRS – Benefits
• More timely and comprehensive road weather reports in RCRS
• Reduced DOT staff time
• Helps meet 23 CFR 511 requirements
• Engages and builds relationships with the public

In **Wyoming**, the department developed the Enhanced Citizen Assisted Reporting (ECAR) feature in 2005, and by 2014 it had over 400 citizens sharing information about road conditions and other incidents they observed on the road. A typical ECAR volunteer is someone who regularly drives a particular stretch of road, and possibly has been doing so on a long-term basis. These include truckers and private citizens. Wyoming has indicated that the citizen reporting program is a cost effective method for gathering more timely and accurate information, meeting the requirements of 23 CFR 511, and also engaging the public in a positive experience with the department.

In 2013, **Idaho** launched their citizen reporting system. Unique aspects of the Idaho system are that all entry is performed using an Internet/mobile device interface; and that citizens may only report for the pre-defined segments that they have registered to receive information about (an indication that they travel those segments regularly). During the initial year of operation, the Idaho Transportation Department (ITD) reported that they were happy with the accuracy and timeliness of the reports received.

Utah also deployed their citizen reporting system in 2013, as a method of supplementing the reports from plow operators observing conditions. Utah DOT has a strong relationship with the Utah Trucking Association, and has invited members of this organization as well as other members of the traveling public to be volunteers with an ultimate goal of 800-1,000 trained volunteers. During the first winter of operation, Utah trained 475 volunteer reporters who submitted a combined total of 1,800 reports on 120 of the 145 road segments, with a self-reported accuracy rate of over 99%.

Emerging Best Practice #2: Integrating Transit Data into the RCRS

As initiatives such as integrated corridor management are deployed, the delivery of transit information tied to highway travel reports will become more important. An emerging best practice that was noted by two agencies is the integration of real-time transit information into the RCRS. The idea of transit reporting into the RCRS is for the system to ingest updates describing the status of buses (either collected automatically or manually entered) so that delayed buses can be treated as events in the RCRS and information describing the delays can be provided to travelers using the dissemination mechanisms tied to the RCRS. A common element among transit system interfaces with the RCRS is that transit routes and schedules (i.e., departure times at each stop) are typically stored in the RCRS, allowing for traveler information systems to disseminate both planned and updated departure times based on current conditions.

Emerging Best Practice Status: Two examples of the integration of transit information into a RCRS were identified. Many agencies track the status of buses, therefore there appears to be great potential to integrate such systems with RCRSs combined with the added benefit of leveraging established dissemination mechanisms for overall information in the RCRS.

Success Stories

In **Sacramento**, the Sacramento Area Council of Governments (SACOG) RCRS is designed to include transit routes operated by local transit agencies. Transit agencies use the RCRS to enter descriptions of events impacting transit service, such as buses behind schedule, bus stop closures, or changes in service. Events entered by transit staff are then delivered using the same information dissemination systems used to share highway incidents, delays, etc. In this example, travelers hearing about major delays impacting their morning drive could also hear about transit issues (or lack thereof) and this could allow better consideration of whether transit is a preferred commute alternative. A secondary benefit of the SACOG transit integration is that the RCRS outputs the transit information in the GTFS XML output, allowing inclusion in the Google Transit Trip Planner website. SACOG also has plans to integrate automated vehicle schedule adherence data that is typically generated through on-board Automated Vehicle Location (AVL) systems to reduce the need for manual updates of vehicle status. Other benefits of the integration include:

- Increased real-time information available on the Google Transit Trip Planner in the Sacramento area; and
- Increased ability for transit operators to enter status updates that inform riders of operational status of vehicles and delay.

In **Idaho**, the Idaho Transportation Department (ITD) has worked with 9-10 transit systems in Idaho and in neighboring states (where routes extend into Idaho) to add transit information to their RCRS. This integration has included the largest transit provider in the state (approximately 50 buses) as well as small transit providers (as few as one bus). Individual transit agencies enter conditions that include delayed buses or closed stops, and the information is disseminated through ITD traveler information systems. ITD also has plans to integrate schedule adherence data generated by AVL data in the near future.

Emerging Best Practice #3: Integration of Third Party Data

As noted earlier, travel time information (a requirement for selected roads in 23 CFR 511) is too time critical and changes too frequent to be manually entered. Therefore, some mechanism for automated collection or calculation is needed. There are many examples of public agencies using field equipment (e.g., loops, radar detectors, blue tooth readers) to collect and compute travel times, speeds or other indicators of traffic flow. An emerging best practice is the inclusion of third party data into the RCRS. Third party data can refer to data that is purchased from a private sector vendor or data received from other public entities (such as data from a public toll facility). Third party data is viewed by some as an alternative to deploying additional publicly owned infrastructure on the roadside that requires ongoing maintenance. A key element common among third party integration into the RCRS is the automated (no human intervention) ingest of data combined with logic to assign the data to the corresponding segments of road. Agencies differ in how they handle the speed or travel time data, with some agencies simply using the data to color maps on websites and other agencies using the data to automatically create events in the RCRS that could be announced on 511 phone systems or HAR broadcasts.

Emerging Best Practice Status: Five examples of third party data ingests into RCRS were reviewed as part of this project. In each case the agencies are having success with the operations. This practice was identified as emerging because the third party data industry is still developing, and there are a variety of agencies considering third party data agreements.

Success Stories

In **New York**, NYSTA ingests travel time data from TRANSCOM's System for Managing Incidents and Traffic (TRANSMIT). TRANSMIT aggregates all the toll tag reads from E-ZPass to generate travel time data that is completely void of any personal information about any individual vehicles. The volume of E-ZPass equipped vehicles allows for accurate reporting of travel times. Once the travel time data is in the NYSTA RCRS, the times are used to generate travel times for key segments of the toll way. These travel times are then disseminated on DMS reporting travel to downstream landmarks, on the website, and through HAR broadcasts. The NYSTA RCRS also includes functionality that considers the TRANSMIT travel time data and automatically generates events describing locations of slow traffic.

Integration of Third Party Data into RCRS – Benefits
• Increased information available to travelers
• Reduces DOT owned infrastructure
• Allows travelers to avoid areas with slow speeds
• Helps meet 23 CFR 511 requirements

In **Maryland**, the Maryland State Highway Administration (MDSHA) purchases private sector data on roadway speeds and integrates the speeds into the RCRS to develop speed and travel time reports. INRIX, a third party data provider, delivers data in a link-based format for MDSHA's CHART system to assess and develop into reports about speed and travel time on state roadways. CHART also determines which DMS to activate with an incident report once it is developed, and the reports are also shared via the MDSHA traveler information web site.

The **Ohio** DOT (ODOT) purchases roadway data from two third party data providers (SpeedInfo and INRIX) to provide travel times in and between their major urban areas throughout the state. The department prescribes the format of the data from both sources. The data is polled every minute during the day and every five minutes during the evening hours to conserve energy consumption from the roadside devices that are used to collect some of the data. The data is integrated with their RCRS to provide travelers with automated travel time information in and between key urban areas around the state. ODOT also requires both vendors to provide a confidence score on their data. The confidence score is self-reported and this was closely checked by ODOT staff in the early stages of deployment to establish confidence in the quality of the data and self-reporting process.

In **California**, data is collected from over 25,000 individual detectors on freeways throughout the state and included in the Caltrans Performance Measurement System (PeMS). The Sacramento Area Council of Governments (SACOG) RCRS then ingests real-time speed, volume, and occupancy data for freeways in the Sacramento area from PeMS. The SACOG RCRS includes an automated ingest of detector data for freeways in and around the Sacramento area. The SACOG RCRS operates a function that analyzes the speed data from PeMS to automatically create events in the RCRS describing slower than normal traffic conditions. Slow traffic described as an event on a road between two locations allows the slow traffic report to be disseminated over the 511 phone system and DMS messages, or sent to travelers using an email alert system and social media outlets.

In **Texas**, Texas DOT (TxDOT) fuses together multiple data sources to generate travel time reports. These data sources include loop detectors, radar, blue tooth readers, and third party data acquired through various agreements. The travel time data sources are denser in the metropolitan areas, and rural areas rely more on third party data. The travel times are fused together to create travel time reports.

Chapter 5. Benefits and Conclusions

As noted earlier, many agencies operating traveler information systems now rely on a RCRS as the central clearinghouse of information. This chapter first presents a summary of the benefits of RCRS use, as well as a summary of the benefits that public agencies could expect if they implemented some combinations of the industry practices described in this report. Concluding remarks are provided at the end of this chapter.

Overall Benefits

The creation of the Internet and the designation of the three digit 511 phone number for traveler information, together with federal initiatives to advance nationwide traveler information, were all catalysts for significant advances in traveler information. Still, although the Internet and 511 phone designation are key information dissemination options to deliver information to travelers, the quality and timeliness of the information relies on a stable source. RCRSs now serve as the stable repository for various data and information types associated with locations along the road network that make the creation of maps, text descriptions or spoken announcements straight-forward. Therefore, in many ways the creation and evolution of RCRSs is yet another catalyst that has helped advance traveler information to the state it is in today. Some benefits of RCRS use include:

- A structure that allows one central repository of data and information describing all types of transportation events that can feed multiple information dissemination mechanisms;
- Multiple users within multiple agencies can enter and edit events in one central RCRS, allowing for the fusion of data and dissemination of traveler information that includes multiple jurisdictions;
- RCRSs often locate events against an established road network, allowing for events to be described according to their starting and ending points along a highway, and enabling automated spoken announcements, text displays or map displays of events;
- RCRSs can serve as a clearinghouse, allowing data and information sharing with other traveler information providers who will disseminate the information to their customers; and
- As travelers' expectations have changed with new technologies and the use of mobile devices, RCRSs have provided an easy transition into information delivery that now includes social media outlets. Looking toward the future, whatever the next generation information dissemination approaches are, RCRSs will most certainly provide the common clearinghouse of data and information.

Benefits of Industry Practices Described in This Document

Roadwork Information Assembly

Three industry practices were identified in this project specifically related to roadwork information assembly into an RCRS. These industry practices all related to increasing the number of roadwork events in the RCRS and improving the accuracy and comprehensiveness of the reports, therefore helping agencies achieve and maintain compliance with 23 CFR 511 requirements. Although the actual benefits will depend upon the specific practices deployed, the following are examples of the general benefits achieved through the industry practices related to roadwork information assembly:

- Reduced workload entering roadwork in multiple systems;
- Increased percentage of road work activities included; and
- Increased detail and timeliness of information describing road work.

Incident / Event Information Assembly

Nine industry practices were identified in this document related to incident and event entry into the RCRS. These practices include modules for automated incident entry as well as staffing approaches and partnership ideas that help encourage timely manual entry. Therefore, each of these practices can help agencies achieve the requirements of 23 CFR 511. The actual benefits will depend on the specific industry practice deployed, but following are examples of general benefits provided by the industry practices associated with information and event information assembly:

- Reduced workload and operator costs to perform incident entry;
- Increased number of incident/event information;
- Increased details about incidents and events included;

- Increased timeliness of incident/event updates;
- Automatic source of performance management information; and
- Improved sharing of resources between DOT and law enforcement centers to accommodate 24-hour coverage.

Road Weather Information Assembly

The research in this project identified a total of 12 industry practices that offer benefits to agencies in the area of road weather information assembly. The practices include approaches for automated ingest of road weather data, as well as strategies for assembling and entering manual reports. Each industry practice has the potential to help agencies meet the 23 CFR 511 requirements for road condition reporting. Depending upon which road weather related industry practices are deployed, agencies might expect the following benefits:

- Reduced workload and operator costs to perform road weather event entry;
- Increased coverage of road condition descriptions;
- Additional data from new sources adds new perspective to understanding road conditions;
- Increased accuracy and timeliness of road weather descriptions;
- Improved sharing of resources between DOT and law enforcement centers to accommodate 24-hour coverage; and
- Improved understanding of relationships between weather and crashes.

Travel Time Information Assembly

Five industry practices were cited to support travel time information assembly. Each described options for automated ingest of speed or travel time data, and each could help agencies achieve the requirements of 23 CFR 511. Depending upon which travel time related industry practices are deployed, agencies might expect the following benefits:

- Increased travel time and speed information available to travelers;
- Reduced workload and operator costs to manually enter traffic events;
- Increased accuracy and timeliness of travel time information; and
- Better operator observations of broader network traffic conditions.

Transit Information Assembly

Two industry practices were identified integration of transit information with RCRSs. Although there are no specific 23 CFR 511 requirements for transit information currently, these industry practices were documented to illustrate the following potential benefits if implemented:

- More comprehensive traveler information by combining transit and highway traveler information data in one source;
- Additional opportunity for travelers to compare information about and choose among modes of transportation; and
- Added benefit of allowing RCRSs to exchange data with Google Transit Trip Planner using the GTFS protocol.

Other Benefits of Industry Practices

In addition to the practices directly related to traveler information, a total of 18 additional practices were identified and categorized as industry practices related to:

- Regional integration and interoperability;
- Data reliability, accuracy, and timeliness;
- Funding and managing RCRS development and system changes; and
- Balancing between all the possible RCRS features and those that are most practical.

Collectively, these industry practices offer a variety of benefits, including:

- Reduced RCRS development and maintenance costs;
- More efficient management of RCRS changes and enhancements;
- Sharing of lessons learned with other agencies operating similar RCRSs;
- Leveraging enhancements across multiple agencies;
- Flexibility in software design; and
- Improved performance measure reporting.

Conclusions

In 2014, the vast majority of travelers throughout the United States are connected to sources of traveler information from the time they conceive a trip through the completion of the trip. Expectations are high for timely, comprehensive information that helps ensure efficient and safe travel. With support from several federal initiatives in recent years, state and local DOTs now operate comprehensive data and information assembly and dissemination systems that meet these expectations to the extent possible. An RCRS is a key element of the overall framework of systems that make traveler information possible. As a result, a typical DOT now includes the operation and management of their RCRS as a 'mission critical' function. Despite this designation, each DOT has to operate and manage their RCRS at a time when budgets are restricted and available funding is limited. Fortunately, the role of RCRSs is similar across most DOTs. This creates an environment where technology transfer and sharing of lessons learned from one agency to another can have tremendous benefits. As such, this document has identified numerous industry practices for RCRS development, use and management that have already benefitted transportation agencies and can be further leveraged by others.

The four most significant trends that appear throughout the industry practices are:

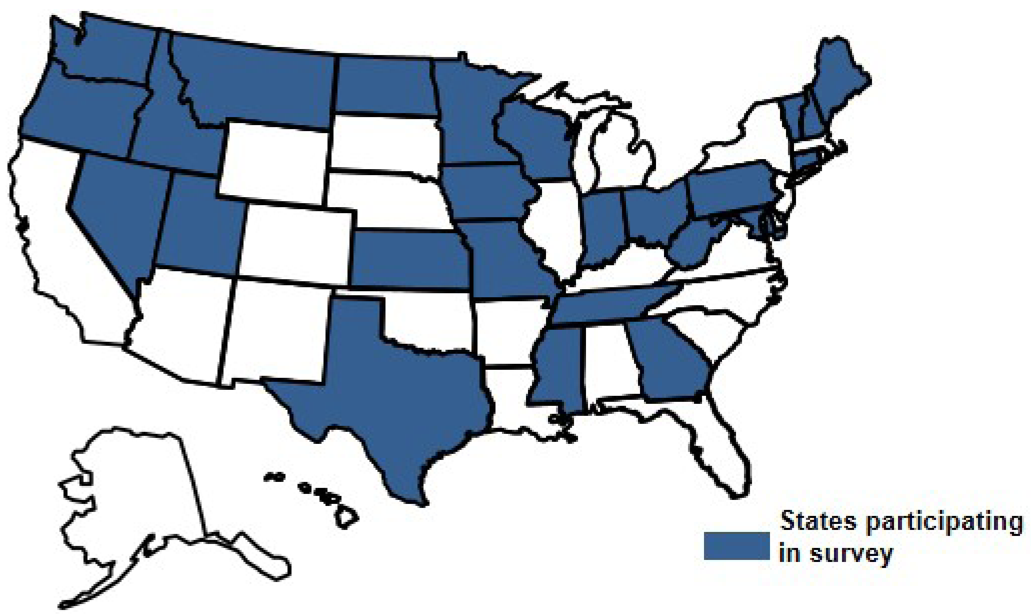
- A movement toward increased automated entry or ingest of data describing events and conditions;
- Combining reporting activities and forming partnerships to reduce workload and avoid duplicating activities;
- Joint development and collaboration to develop and enhance RCRSs; and
- Creating RCRS architectures that enable performance measure reporting directly from the RCRS.

Appendix A - Survey Results

Question 1: Agencies Participating in Survey

Survey contributors were asked to enter the name of the agency they represented.
Responses were received from the following twenty-five (25) states as shown in Figure 2.

- Connecticut
- Georgia
- Idaho
- Indiana
- Iowa
- Kansas
- Maine
- Maryland
- Minnesota
- Mississippi
- Missouri
- Montana
- Nevada
- New Hampshire
- North Dakota
- Ohio
- Oregon
- Pennsylvania
- Tennessee
- Texas
- Utah
- Vermont
- Washington State
- West Virginia
- Wisconsin

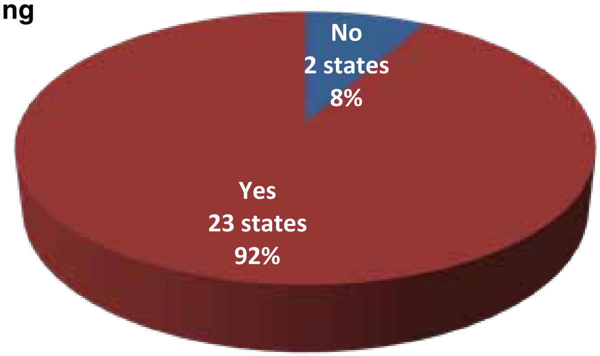


Question 2: Agencies Using RCRS

Survey contributors were asked if their agency is using a RCRS.

Respondents from twenty-three (23) of the states that responded indicated that their agency uses a RCRS. Respondents from the following two (2) states indicated that they are not using a RCRS:

- New Hampshire Department of Transportation (DOT)
- Georgia DOT (Note: Georgia DOT responded 'Yes' to the follow-up question that would indicate they use an RCRS, but did not complete additional questions.)



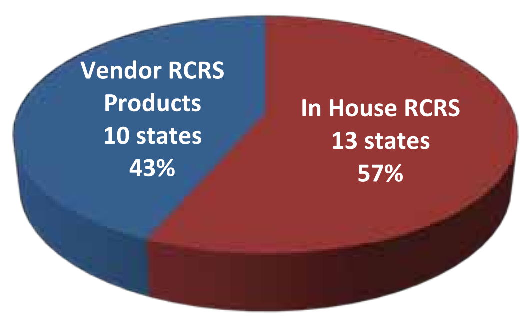
Question 2: Is your agency using RCRS?

Question 3: Type of RCRS Used

Survey contributors were asked which RCRS they are using.

Respondents from thirteen (13) states indicated their RCRS was developed in house. Respondents from nine (9) states indicated use of vendor RCRS products.

RCRS Product	State
In-House	• Connecticut • Kansas • Maryland • Mississippi • Missouri • Montana • North Dakota • Ohio • Oregon • Pennsylvania • Tennessee • Vermont • Washington
Volt Delta	• Nevada
Transcore TranSuite ATMS	• Wisconsin • Utah
Open TMS – Open Roads Consulting Inc.	• West Virginia
Condition Acquisition Reporting Systems (CARS) – Castle Rock	• Idaho • Indiana • Maine • Minnesota
Lonestar	• Texas



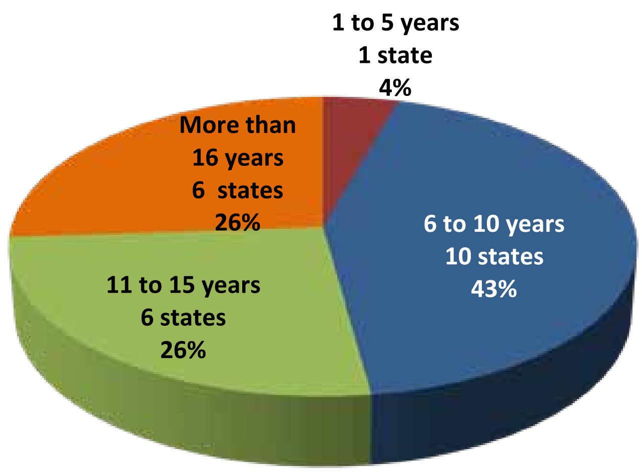
Question 3: What RCRS is your agency using?

Question 4: Duration of RCRS Use

Survey contributors were asked how long their agency has been operating RCRS.

Respondents in six (6) states have been operating their RCRS between 11 and 15 years and respondents in ten (10) states have been operating their RCRS between 6 and 10 years.

Number of Years Operating RCRS	State
1 to 5 years	• West Virginia
6 to 10 years	• Connecticut • Idaho • Indiana • Maine • Missouri • Ohio • Pennsylvania • Tennessee • Utah • Washington
11 to 15 years	• Iowa • Kansas • Minnesota • Mississippi • Oregon • Vermont
More than 16 years	• Maryland • Montana • Nevada • North Dakota • Texas • Wisconsin



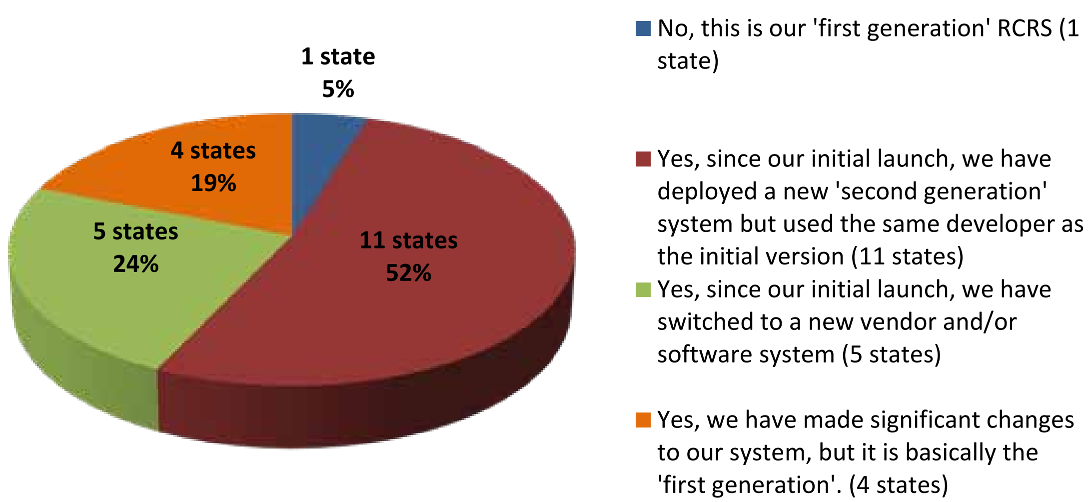
Question 4: How long has your agency operated a RCRS?

Question 5: RCRS Changes

Survey contributors were asked if they have made any significant changes to their RCRS since it initially launched.

Twenty-one (21) responses were received to this question. Half of the respondents indicated that they have deployed a second generation RCRS and have used the same developer for both versions. Approximately one-fourth of the responders indicated that they switched to a new vendor and/or software systems since their initial RCRS launch. One (1) state respondent (West Virginia) indicated that their RCRS is a first generation system. Overall comments received indicate that changes are needed to continually evolve and improve RCRS. Specific comments received on the history of RCRS in some states included:

- Pennsylvania DOT, which uses an in-house RCRS, implements 3 to 4 enhancements per calendar year to their system. Maryland has been adding 2 to 3 major releases to their RCRS each year since 2006.
- Oregon DOT's new RCRS version is integrated with their dispatch/incident management system. This new system avoids duplicate entry into both systems.
- The Vermont Agency of Transportation initially deployed CARS for their RCRS. In 2012 an in-house system was developed by Vermont while working with New England states on a new regional RCRS.

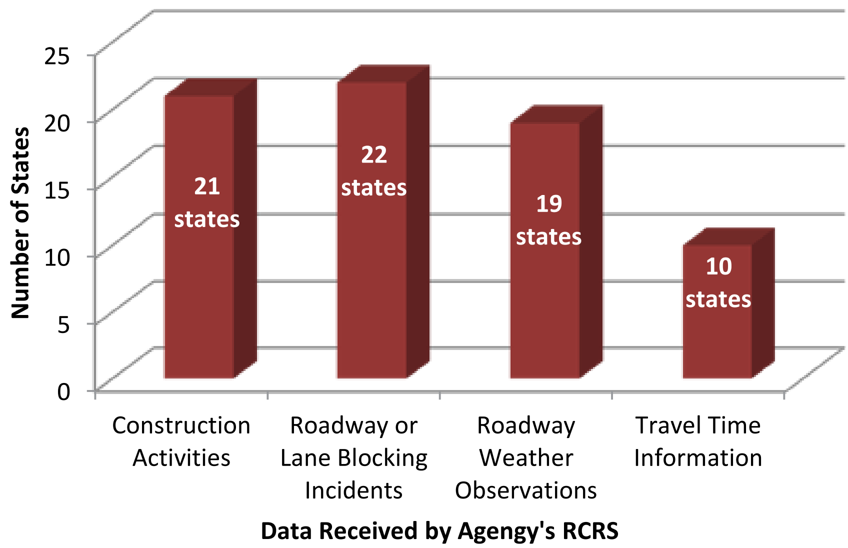


Question 5: Have you made any signifcant changes to your RCRS since you intially launched it?

Question 6: RCRS Data Received

Survey contributors were asked what data is received by their agency's RCRS.

Respondents in over nineteen states indicated that construction activities, roadway or lane blocking incidents, and road weather observations were received by their agency's RCRS. Ten respondents indicated that their RCRS received travel time information.



Question 6: What data is received by your agency's RCRS?

Other Data/Information Received by RCRS	State
Chain Requirements	• Oregon • Nevada
CCTV	• Idaho • Nevada
DMS	• Nevada
Special Event Information	• Nevada • Oregon • Wisconsin
Road Conditions	• Montana
Load/Truck Restrictions	• Iowa • Minnesota • Montana • Oregon
Speed Restrictions	• Montana
Weather Radar	• North Dakota
Wind speed	• North Dakota

Other Data/Information Received by RCRS	State
Maintenance Activities	• Oregon • West Virginia
Non-blocking Incidents	• Oregon
Travel and Tourism	• Vermont
Point Speed Detection	• Maryland
Automated Vehicle Location from State Vehicles	• Maryland
RWIS	• Maryland • Idaho
Impaired Traffic Signals	• Maryland
National Weather Service	• Idaho • Iowa
Traffic Speeds	• Iowa

Question 7: RCRS Data Entry

Survey contributors were asked how data received by RCRS is entered (manual, semi-automated or fully automated).

Respondents indicated that travel times received by RCRS are fully-automated. Respondents noted that construction activity data received by RCRS are manually entered and semi-automated. Respondents indicated that roadway or lane blocking incidents and roadway weather observations data is received by RCRS by manual data entry, semi-automated systems, and fully-automated systems. A summary is provided in the table below.

Respondents noted that CCTV, DMS, traffic speeds, radar and wind speeds are an automated entry into some agencies RCRS. Manual entries noted by respondents for some RCRS included chain requirements, special events, truck restrictions and maintenance activities.

Data Received by RCRS	Manual Entry	Semi-Automated Entry	Fully Automated Entry
Construction Activities	20 states ID, IN, IA, KS, ME, MN, MS, MO, MT, NV, ND, OH, OR, PA, TN, TX, VT, WA, WV, WI	2 states CT, MA	0 states
Roadway or Blocking Inci-dents	17 states ID, IN, IA, KS, ME, MS, MO,MT, NV, ND, OH, OR, PA, TN, TX, VT, WA	3 states CT, MA, WI	2 states MN, WV
Roadway Weather Observations	12 states ID, IN, IA, KS, ME, MO, ND, PA, TN, TX, UT, WI	3 states MA, MI, VT	3 states OH, OR, WA
Travel Time Infor-mation	0 states	0 states	12 states ID, KS, MA, MI, MN, NV, OH, OR, TN, TX, WA, WI

Question 8: RCRS Data Frequency

Survey contributors were asked how frequently the data is received by their RCRS.

In order to understand each respondent's ability to meet the SAFETEA-LU Section 1201 Real-Time System Management Information Program (RTSMIP) requirements, the survey asked responders to indicate the frequency at which different data types are updated in the RCRS. The following table describes the Section 1201 requirements.

Section 1201 Requirements Overview

Data Received by RCRS	Interstates – Outside Metro	Interstates – Within Metro	Metro Area Routes of Significance
Construction Activities	20 minute latency from time of closure	10 minutes latency from time of closure	10 minutes latency from time of closure
Roadway or Blocking Incidents	20 minute latency from time of verification	10 minute latency from time of verification	10 minute latency from time of verification
Roadway Weather Observations	20 minute latency from observation	20 minute latency from observation	20 minute latency from observation
Travel Time Information	N/A	10 minute latency from calculation	10 minute latency from calculation

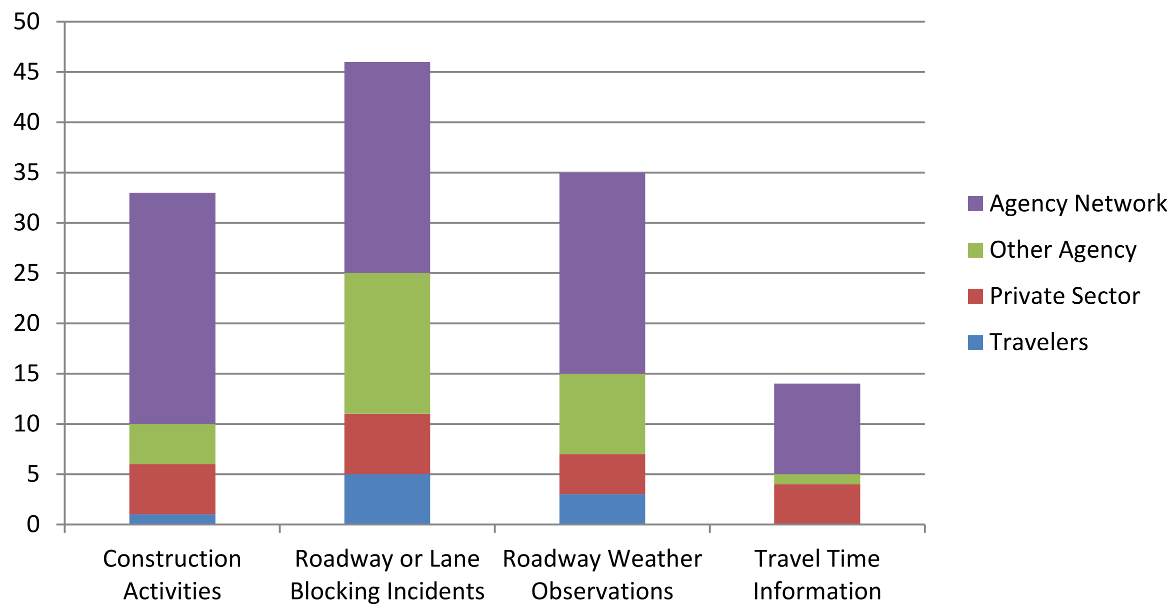
Respondents indicated that data (construction activities, roadway or lane blocking incidents, roadway weather observations, and travel time information) is most frequently updated within 10 minutes of observation as show in the table below.

Data Received by RCRS	Within 10 minutes of observation	Within 20 minutes of observations	On a regular schedule, regardless of whether conditions change	Daily
Construction Activities	12 states CT, IA, IN, MA, MO, MS, ND, OH, OR, TN, VT, WI	0 states	3 states ME, MT, WI	5 states KS, MN, TX, WI, WV
Roadway or Blocking Incidents	16 states CT, IA, ID, IN, MA, MN, MO, MS, ND, NV, OH, OR, TN, TX, VT, WI	4 states KS, ME, MT, WV	0 states	0 states
Roadway Weather Observations	11 states IA, IN, MA, MO, MS, ND, NV, OH, OR, TN, VT	3 states KS, MT, TX	6 states IA, ID, MN, UT, WI, WV	0 states
Travel Time Information	9 states ID, MA, MS, NV, OH, OR, TN, TX, WI		1 state MN	

Question 9: RCRS Data Sources

Survey contributors were asked to identify what sources of data are used for their RCRS.

Respondents were asked if their RCRS data was received from the agency's network, other agencies, the private sector or travelers. Most responded that data is received from the agency network and only a few identified travelers as a data source for construction, incidents and roadway weather conditions.



Question 9: From what source does your RCRS receive data?

Appendix B - Survey Text

RCRS Practices

Introduction

This survey is sponsored by the Federal Highway Administration (FHWA) and the Traffic Management Center Pooled Fund Study (TMC PFS) as they seek to understand the current best practices associated with Road Condition Reporting Systems (RCRS).

Road Condition Reporting Systems are defined as any software tool that is used to enter and store information describing road work, road or lane closures, incidents, or driving conditions. Typically, an RCRS supplies the information for traveler information dissemination systems.

The results of this survey will be used to understand the general state of RCRS practice, particularly as they relate to the Real-Time System Management Information Program. The results will also be used to target some agencies for additional interviews regarding potential RCRS best practices.

1. Please enter the name of the agency you are representing

2. Is your agency using a Road Condition Reporting System (RCRS)?

- Yes
- No

3. What RCRS is your agency using? This may be described as a specific brand name of RCRS or as an in-house RCRS.

4. How long has your agency operated an RCRS?

- Less than 1 year
- 1-5 years
- 6-10 years
- 11-15 years
- More than 16 years

RCRS Practices

5. Have you made any significant changes to your RCRS since you initially launched it?

- ◯ No, this is our 'first generation' RCRS
- ◯ Yes, since our initial launch, we have switched to a new vendor and/or software system
- ◯ Yes, since our initial launch, we have deployed a new 'second generation' system but used the same developer as the initial version
- ◯ Yes, we have made significant changes to our system, but it is basically the 'first generation'.

Please present additional details about the history of your RCRS that you think are valuable.

6. What data is received by your agency's RCRS? Please check all that apply and add others as needed.

- ☐ Construction Activities
- ☐ Roadway or Lane Blocking Incidents
- ☐ Roadway Weather Observations
- ☐ Travel Time Information

Other data received (please specify)

7. For the data received by your RCRS, which are entered in a manual, semi-automated or fully-automated fashion?

	Manual Entry	Semi-Automated Entry	Fully-Automated Entry
Construction Activities	◯	◯	◯
Roadway or Lane Blocking Incidents	◯	◯	◯
Roadway Weather Observations	◯	◯	◯
Travel Time Information	◯	◯	◯

Entry for other data (please specify)

RCRS Practices

8. Please describe how frequently the data received by your RCRS is updated (select more than one option, if applicable).

	Within 10 minutes of observation	Within 20 minutes of observation	On a regular schedule, regardless of whether conditions change	Daily
Construction Activities	☐	☐	☐	☐
Roadway or Lane Blocking Incidents	☐	☐	☐	☐
Roadway Weather Observations	☐	☐	☐	☐
Travel Time Information	☐	☐	☐	☐

Update frequency for other data (please specify)

9. From what sources does your RCRS receive data? Check all that apply, you may select more than one answer for each row.

	Agency Network	Other Agency	Private Sector	Travelers
Construction Activities	☐	☐	☐	☐
Roadway or Lane Blocking Incidents	☐	☐	☐	☐
Roadway Weather Observations	☐	☐	☐	☐
Travel Time Information	☐	☐	☐	☐

Sources of other data (please specify)

Responders who answer 'no' to question 1

10. Your response indicated that your agency does not operate a Road Condition Reporting System. Do you have any tool (e.g. software, spreadsheet, database, etc.) that is used to store information about construction events, lane or road closures, incidents, or driving conditions?

◯ Yes <<Note: Responders who answer yes to this question will be returned to the survey and asked to provide information about this tool>>

◯ No, we don't have the need for road condition reporting;

◯ No, but we are in the process of planning and/or developing a reporting system.

Please provide any details you think would be valuable

RCRS Practices

Conclusion

On behalf of FHWA and the TMC PFS, thank you for your time and the information you've provided for this survey.

If you would like additional information about this survey or the RCRS best practices project, please contact Jeremy Schroeder, Project Manager -Battelle, 202.479.4191. schroederj@battelle.org

Appendix C - Interview Contacts

The following individuals provided information describing the RCRS used by their agency and/or were identified as contacts for additional information. Contacts are listed by agency.

Agency	Name	Email	Phone	Category
Alaska Department of Transportation and Public Facilities	Lisa Idell-Sassi	lisa.idell-sassi@alaska.gov	907-465-8952	• Mapping and Geodatabase Representation of Linear Events
Florida Department of Transportation				• Integrating RCRS Event Entry with DOT Dispatch or Traffic Management Activities • Automated Field Devices Message Selection/Creation Based on Events in RCRS • Integration with Field Equipment (DMS controllers or signs, HAR controllers) • Collaboration in Development of RCRS • RCRS Design and Architecture
Idaho Transportation Department	Tony Ernest	tony.ernest@itd.idaho.gov	208-334-8836	• Automatic or Manual Entry of Weather or Driving Condition Information into RCRS • Integrating RCRS Event Entry with DOT Dispatch or Traffic Management Activities • Citizen Entry into RCRS • Transit Information Integrated in RCRS • Balancing Available Data with Data the Public Needs in RCRS
Iowa Department of Transportation	Sinclair Stolle	sinclair.stolle@dot.iowa.gov	515-239-1933	• Automatic or Manual Entry of Weather or Driving Condition Information into RCRS • RCRS Change Management, Training and Use
Maryland State Highway Administration	Rick Dye	rdye@sha.state.md.us	410-582-5619	• Automatic or Manual Entry of Weather or Driving Condition Information into RCRS • Entering and Updating Road Work and Other Planned Lane Closures in RCRS • Automated Ingest of Speed or Travel Time Information • Automated Performance Measure Outputs for State and Federal Reporting

Agency	Name	Email	Phone	Category
Michigan Department of Transportation	Oloadayo (Dayo) Akinyemi	akinyemio@michigan.gov	313-256-9802	• Entering and Updating Road Work and Other Planned Lane Closures in RCRS
Minnesota Department of Transportation	Kelly Braunig	kelly.braunig@state.mn.us	651-234-7026	• Law Enforcement CAD Integration with RCRS
Nevada Department of Transportation	Denise Inda	dinda@dot.state.nv.us	775-888-7867	• Software Development and Management • RCRS Design and Architecture
New Jersey Department of Transportation	Jim Hadden	james.hadden@dot.state.nj.us	609-530-2938	• Automated Performance Measure Outputs for State and Federal Reporting
New York State Thruway Authority	Chris Jones	chris_jones@thruway.state.ny.us	518-436-2814	• Law Enforcement CAD Integration with RCRS • Automated Ingest of Speed or Travel Time Information • Automated Field Devices Message Selection/Creation Based on Events in RCRS • Integration with Field Equipment (DMS controllers or signs, HAR controllers) • Balancing Available Data with Data the Public Needs in RCRS
North Dakota Department of Transportation	Brad Darr	bdarr@nd.gov	701-328-4443	• Automatic or Manual Entry of Weather or Driving Condition Information into RCRS
Ohio Department of Transportation	Merih Ocbazghi	merih.ocbazghi@dot.state.oh.us	614-466-1290	• Automatic or Manual Entry of Weather or Driving Condition Information into RCRS • Automated Ingest of Speed or Travel Time Information
Oregon Department of Transportation	Galen McGill	galen.e.mcgill@odot.state.or.us	503-986-4486	• Automatic or Manual Entry of Weather or Driving Condition Information into RCRS • Integrating RCRS Event Entry with DOT Dispatch or Traffic Management Activities • Automated Performance Measure Outputs for State and Federal Reporting • RCRS Change Management, Training and Use • Balancing Available Data with Data the Public Needs in RCRS

Agency	Name	Email	Phone	Category
Sacramento Area Council of Governments	Mark Heiman	mheiman@sacog.org	916-340-6232	• Automated Ingest of Speed or Travel Time Information • Transit Information Integrated in RCRS • RCRS Design and Architecture • Balancing Available Data with Data the Public Needs in RCRS
Texas Department of Transportation	Alex Power	alex.power@txdot.gov	512-517-0602	• Automated Ingest of Speed or Travel Time Information • Collaboration in Development of RCRS
Utah Department of Transportation	Jeff Williams	jeffwilliams@utah.gov	801-887-3735	• Automatic or Manual Entry of Weather or Driving Condition Information into RCRS
	Lisa Miller	lisa.miller@utah.gov	801-887-3761	• Citizen Entry into RCRS
Washington State Department of Transportation	Bill Legg	leggB@wsdot.wa.gov	360-705-7994	• Integrating RCRS Event Entry with DOT Dispatch or Traffic Management Activities • Software Development and Management • RCRS Change Management, Training and Use • RCRS Design and Architecture
Wisconsin Department of Transportation/ University of Wisconsin	Peter Rafferty	prafferty@wisc.edu	608-890-1218	• Law Enforcement CAD Integration with RCRS • Entering and Updating Road Work and Other Planned Lane Closures in RCRS • Software Development and Management • RCRS Design and Architecture
Wyoming Department of Transportation	Vince Garcia	vince.garcia@wyo.gov	307-777-4231	• Automatic or Manual Entry of Weather or Driving Condition Information into RCRS • Citizen Entry into RCRS

Endnotes

[1] The current generation of CHART was developed in-house by MDSHA through a contract with Computer Sciences. The CHART software is freely available for use by other agencies.

[2] The WisDOT Lane Closure System was developed by the University of Wisconsin-Madison Traffic Operations and Safety (TOPS) Laboratory.

[3] MnDOT uses CARS for their RCRS. The CAD system is provided by Intergraph. The integration with the MSP CAD is performed through a CARS module called, "CARS-Import." The contractor that developed and currently maintains CARS and CARS-Import is Castle Rock Associates.

[4] The NYSTA RCRS is the Condition Acquisition and Reporting System (CARS), developed in collaboration with the CARS Consortium. The contractor is Castle Rock Associates.

[5] WVDOT operates Open TMS as both an ATMS and an RCRS system. The contractor that developed Open TMS is Open Roads Consulting.

[6] The WisDOT ATMS System is a TransCore product.

[7] The Oregon DOT RCRS is a software system developed in-house by ODOT. Some modules have been contracted for development, however all ownership resides with ODOT. The system is a client server based system, with a web interface for those operators not in an ODOT TOC.

[8] The Florida SunGuide software system is a state owned software system that utilizes software from both TxDOT as well as software developed by Florida DOT. Florida and Texas DOT are collaborating in development and sharing their enhancements with the other. The contractor that developed the system is Southwest Research Institute (SwRI).

[9] The WSDOT RCRS "ROADS" was developed and is supported by in-house WSDOT software programmers. The Radio Log was also developed and is supported by in-house WSDOT software programmers.

[10] The ITD RCRS is the Condition Acquisition and Reporting System (CARS) developed in cooperation with the CARS Consortium. The contractor that developed the CARS system is Castle Rock Associates.

[11] The Wyoming DOT uses the Wyoming Travel Information (WTI) system, which is an in-house developed RCRS.

[12] Utah DOT utilizes a variety of systems in the Statewide TOC. The Citizen Entry System is a new software system that allows users to download an App to perform entry, and the system automatically inserts the road condition reports into the UDOT Traffic Alerts System.

[13] The current generation of CHART was developed by MDSHA through a contract with Computer Sciences. The CHART software is freely available for use by other agencies.

[14] NDDOT's RCRS was developed and is maintained by in-house staff. The department is currently operating its second generation system.

[15] Buckeye Traffic was developed and is maintained in-house by ODOT staff. In addition to serving as the department's RCRS, Buckeye Traffic is also used for control of several traffic management devices including DMS, HAR and CCTV.

[16] The SACOG RCRS is the Condition Acquisition and Reporting System (CARS), developed in collaboration with the CARS Consortium. The contractor is Castle Rock Associates.

[17] The Iowa RCRS is the Condition Acquisition and Reporting System (CARS) developed in cooperation with the CARS Consortium. Iowa DOT is the lead state for the CARS Consortium. The contractor that developed the CARS system, and this module, is Castle Rock Associates.

[18] The AKDOT&PF RCRS is called 511 RIDE. The contractor that developed 511 RIDE and the related AK 511 Website is Open Roads Consulting.

[19] USDOT, Computer-Aided Dispatch – Traffic Management Center Field Operational Test: Washington State Final Report (2006).

[20] USDOT, Computer-Aided Dispatch – Traffic Management Center Field Operational Test: State of Utah Final Report (2006).

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Office of Operations
1200 New Jersey Ave., SE
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