Meeting the Real-Time Systems Management Information Program Requirements: A Survey of State Agency Efforts

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ABSTRACT

MEETING THE REAL-TIME SYSTEMS MANAGEMENT INFORMATION PROGRAM REQUIREMENTS: A SURVEY OF STATE AGENCY EFFORTS

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Federal Regulation 23 CFR 511 promises to improve the traveler information that assists motorists to make better travel decisions. In accordance with this regulation, all state departments of transportation (DOTs) are required to provide real-time traveler information including construction activity, lane blocking incidents, adverse weather conditions, and travel-times on certain facilities, by November 8, 2014. In this thesis, the researcher used an online survey to collect information from State DOTs and their associated representatives from the US Federal Highway Administration (FHWA). A survey was distributed electronically to FHWA representatives, State DOT Operations Engineers, and State DOT Intelligent Transportation Systems Coordinators who were active in the implementation of their agency's real-time systems management information program. The survey results illustrated that field data was most frequently processed into travel times with software from vendors, and the majority of the agencies used the accuracy thresholds required by the new rule. According to the survey results, the most common way that DOTs gather construction lane closure information is by requiring the contractors to provide this information using existing specifications and special provisions. The survey results indicated that most of the agencies operate 24 hours a day; therefore, they do not have problems providing the incident information to the public. Overall the findings of this study are relevant to both practitioners and researchers

in transportation engineering because they detail current reported practices of how DOTs are collecting, processing, and disseminating travel time, construction, incident, and weather data, and how DOTs are measuring the quality of the data.

DISCLAIMERS

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API	Application programming interface
ATIS	Advanced Traveler Information System
AVI	Automatic vehicle identification
AVL	Automated vehicle location
CAD	Computer-aided dispatch
CARS	Condition Acquisition and Reporting System
CCTV	Closed-circuit television
CFR	Code of Federal Regulations
CVRIA	Connected Vehicle Reference Implementation Architecture
DMS	Dynamic message sign
DOT	Department of Transportation
DXFS	Data Exchange Format Specification
ESS	Environmental sensor station
FHWA	Federal Highway Administration
GPS	Global positioning system
HAR	Highway Advisory Radio
HOT	High-occupancy toll

ICT	Illinois Center for Transportation
IDOT	Illinois Department of Transportation
IEEE	Institute of Electrical and Electronics Engineers
IRIS	Integrated Roadway Information System
ITS	Intelligent Transportation Systems
MADIS	Meteorological Assimilation Data Ingest System
MSA	Metropolitan Statistical Area
NWS	National Weather Service
PSAP	Public safety answering point
RTMC	Regional Traffic Management Center
RTRDS	Real-Time Route Diversion System
RTSMIP	Real-Time System Management Information Program
RWIS	Roadway Weather Information System
SDDOT	South Dakota Department of Transportation
STOC	State Travel Operations Center
TMC	Traffic Management Center
TOCC	Traffic Operations and Communications Centers
TTS	Text-to-speech

USDOT	U.S. Department of Transportation
V2I	Vehicles-to-infrastructure
V2V	Vehicles-to-vehicles
V2X	Vehicle communications
WisLCS	Wisconsin Lane Closure System
WSDOT	Washington Department of Transportation

CHAPTER 1

INTRODUCTION

Part 511 of Title 23 (Title 23 CFR 511) of the United States Code of Federal Regulations (23 CFR 511), passed November 8, 2010, established provisions and parameters for Real-Time System Management Information Programs (RTSMIPs). In accordance with the federal regulation, all State Departments of Transportation are required to provide real-time travel information (e.g., construction activity, lane blocking incidents, adverse weather conditions and travel times) along U.S. Interstate System Highways as well as routes of significance within MSAs. Title 23 CFR 511 was designed for a two-step implementation of the real-time information programs (23 CFR 511 2010).

First, RTSMIPs are required to be operational for all limited access facilities, such as Interstates, by November 8, 2014. All 50 States, Washington, D.C. and Puerto Rico have Interstates and will be affected by this regulation. While Alaska, Hawaii and Puerto Rico do not have Interstate Highways that connect to the contiguous United States, they all have highways that receive funding through the Interstate program. In total, there are 72 primary Interstates denoted with a one or two digit number, and 153 auxiliary Interstates denoted with three digit numbers. Total miles of interstates, which are being funded by this program are approximately 48,300 miles. Detailed table of the miles of inter sates for each state and the states that have the routes of significance can be found in Appendix A, Table A 1.

Next, RTSMIPs are required to be operational for routes of significance in MSAs by November 8, 2016. State DOTs must collaborate with local or regional agencies to designate non-Interstate routes of significance. When identifying these routes, the following factors should be considered:

- "Roadway safety (e.g., crash rate, routes affected by environmental events)
- Public safety (e.g., routes used for evacuations)
- Economic productivity
- Severity and frequency of congestion, and
- Utility of the highway to serve as a diversion route for congestion locations" (FHWA, U.S. Department of transportation Federal Highway Administration 2010)

Only MSAs with a population greater than 1,000,000 people must comply. According to the 2010 Census, there are 52 MSAs that meet this population requirement which include 38 states, Washington, D.C., and Puerto Rico. The 12 states not affected by this portion of the regulation include Alaska, Hawaii, Idaho, Iowa, Maine, Montana, Nebraska, New Mexico, North Dakota, South Dakota, Vermont, and Wyoming.

Title 23 CFR 511 also includes minimum requirements for timeliness, accuracy and availability of traveler information. When agencies become aware of construction activities that close or reopen roadways or lanes, they must inform the public within 20 minutes for Limited access roadways outside of Metropolitan Areas. Within Metropolitan Areas, information about construction activities that close or reopen roadways or lanes must be provided by transportation agencies within 10 minutes of their notification. Additionally, the timeliness for the availability of information related to traffic incidents blocking roadway(s) or lane(s) must be within 20 minutes of the time that the incident is verified for Limited access roadways outside of Metropolitan Areas. For roadways within Metropolitan Areas, the timeliness of information related to traffic incidents blocking roadway(s) or lane (s) must be within 10 minutes of the time after the incident is verified. Additionally, information about hazardous driving conditions and roadway or lane closures or blockages due to adverse weather conditions must be provided within 20 minutes of the time the hazardous conditions, blockage, or closure is observed. Finally, the timeliness for the availability of travel time information along limited access roadway segments within MSAs must be 10 minutes or less from the time that the travel time calculation is completed. All real-time information programs are required to be 85 percent accurate at a minimum, and must be available at least 90 percent of the time (FHWA, U.S. Department of transportation Federal Highway Administration 2010). These parameters are summarized in Table 1.

Table 1. Data Quality Measures of Effectiveness

	Travel Time	Weather Information	Construction activities	Traffic Incidents
Accuracy	>85%	N/A	>85%	>85%
Availability	>90% of time	>90%	>90%	>90%
Timeliness	<10 min.	<20 min.	<10 min. urban <20 min rural	<10 min. urban <20 min rural

Historically, DOTs have focused their collection and dissemination of real-time traveler information in urban areas. Although some efforts have succeeded in rural traveler information, challenges include collecting consistent and reliable traveler information and availability of technology for real-time data collection (Burgess, Toppen and Harris 2012).

States are required to establish real-time information programs that are consistent with the minimum regulations defined in Title 23 CFR 511. However, the federal regulation does not specify any requirement for the technologies used in the collection. The regulation recommends that the real-time information programs should be established to take advantage of the existing traffic and travel condition monitoring capabilities and build upon them where applicable. Currently, the technologies utilized and the areas covered vary from state to state. Due to the array of technologies available for use, it would be difficult to establish a uniform method for calculating the accuracy and quality of the information. Each state is required to establish a method for ensuring the quality of the information based on the technology being used (FHWA, Part 511- Subpart C 2010).

CHAPTER 2

LITERATURE REVIEW

2-1 Introduction

As technology continues to increase our ability to collect real-time travel information, the public's expectations of those services also grow (T3 Webinar overview 2013). Perceiving this need, the US Federal Government passed a rule that requires all State Departments of Transportation and other transportation agencies to provide real-time travel information and ensure its quality. To meet the rule, states have started to analyze their current Intelligent Transportation System (ITS) infrastructure and travel information collection and reporting processes. The following sections will present the current state of knowledge about travel information, including a review of 1) the recent legislation, 2) travel time information 3) construction travel information, 4) traffic incident information, and 5) weather information for travelers.

According to previous research and case studies (FHWA, U.S. Department of transportation Federal Highway Administration 2013), there is no single best technique for collecting all of the travel information required by this rule; therefore, best techniques should be considered for each type, with an understanding of travelers' use, perception, and responses to each type of travel information. Advancements in technology have made it easier to collect travel information. Data can now be collected using loop detectors, cameras and radar sensors. However, even with current technologies, field data collection is still necessary. Information about how many lanes incidents block and how adverse weather conditions are impacting roads, cannot always be determined using sensors and cameras.

Real time data collection occurs, at some level, at almost all transportation agencies. The most important difference between agencies is the scope of the real-time data collection. Almost every agency collects freeway speed data. In most cases, this is done using agency field equipment, but a subset of agencies purchase the speed data from private companies. For example, the South Carolina Department of Transportation receives near real-time speed data from a private company called INRIX (Bak 2014) under a contractual agreement with the company. INRIX collects speed data through commercial vehicles acting as speed probes (Bak 2014).

Most state agencies have speed data collection capabilities on the freeways near major Metropolitan Statistical Areas (MSAs). Less common, is the collection of real-time speed data for major arterials; although it is becoming more common and is included in many regional ITS application (Technologies, Consensus systems; systematics, Cambridge technologies 2013). This trend is promising because some of these arterials will be considered Routes of Significance, and will require real-time information monitoring under Federal Regulation 23 CFR 511. Examples of the technologies being utilized by states are discussed in the sections that follow.

In 2011, U.S. DOT started developing the Data Exchange Format Specification (DXFS) to simplify the development of interoperable real-time traffic and travel information between the public agencies, other public agencies, and the private entities. The primary goal of DXFS was to establish a standard-based specification for RTSMIPs interfaces. These interfaces include those between traffic, transit, and transportation related weather. While DXFS covers all the information needed in Title 23CFR 511, the scope of the DXFS has been extended to include transit and additional traffic information. DXFS was established to assist transportation agencies, public safety agencies, traveler information providers (public or private), and contractors deploying these systems (Technologies, Consensus systems; systematics, Cambridge technologies 2013). This new specification can be leveraged as a tool to help meet the requirements of the RTSMIP.

In response to the Title 23 CFR 511, states in the North/West Passage Coalition; including Idaho, Minnesota, Montana, North Dakota, South Dakota, Washington, Wisconsin, and Wyoming; have already evaluated their compliance. The findings of their compliance study suggest that the states without a state-wide (urban and rural areas) 511 system in place, consider developing such a system in near future. States without MSAs having a population greater than 1,000,000 were already in compliance. This study recommended establishing a 24/7 traffic control center or partner with agencies to provide information outside of normal business operating hours in support of a 511 traveler information system (Rafferty, Amegashitsi and Koster 2013).

2-2 Previous Work on Travel Time Information

Previous studies on the topic of travel time have measured the accuracy of numerous data collection tools. Early work, published in 2001 described how a travel time prediction system operated in Dayton, Ohio. This system used radar sensors for detecting the vehicle traffic on each highway lane, 220 MHz radios for transmitting data from sensors to the computer and from the computers to the dynamic message signs. To evaluate the accuracy of this system, researchers conducted 119 travel time runs over a three-day period. The accuracy of the predicted travel times was found to be 88% within a range of ±4 minutes from the actual travel time. When the margin of error was reduced to ±2 minutes, the accuracy was found to be between 65-70%. Overall, the travel time accuracy decreased for longer segments (Zwahlen and Russ, Evaluation of the Accuracy of a Real-Time Travel Time Prediction System in a

Freeway Construction Work Zone 2001) (Zwahlen and Russ, Evaluation of the Motoring Public's Acceptance of a Real-Time Travel Time Prediction System in a Freeway Construction Work Zone 2002) (Zwahlen, Evaluation of a Real-Time Travel Time Prediction System in a Freeway Construction Work Zone 2001).

Later, in 2003, a quantitative method was established for evaluating the accuracy of travel time. This first method noted that measuring day-to-day variability was challenging and recommended collecting travel times on the same segment at the same time over many days (at least 20). These recommendations noted that if the accuracy was below 15 percent, additional work should measure the day-to-day variability within the road network (Toppen and Wunderlich 2003).

In metropolitan areas where inductive loop detectors or other speed sensors are typically prevalent, travel times are often estimated by extrapolation of the sensor data. This method estimates travel times based on measurements from many vehicles instead of relying on particular probe vehicles. However, due to the discrete nature of detectors, the spot speed measurements must be extrapolated to estimate travel times across a corridor which can lead to a reduction in accuracy. The emergence of Bluetooth, radar, microwave and other non-invasive detectors has led to increased monitoring and estimating of travel times on arterials and rural roads (Singer, et al. 2013).

The important consideration in measuring ATIS travel time is that the representative sample of data point collection would be ensured. If the detector reliability is not across the network, then the accuracy of different segments can be very different. Additionally, accuracy might be lower during peak hours because inductive loops detectors are less accurate at low speeds. It is a best practice to use probe vehicles to collect ground truth travel times for several routes at various times of the day. As probe vehicle cannot collect the quantity of data that methods such as license plate matching can, widely sampling the network is very important. Based on minimum sample size statistics and the marginal cost of each data point collected, some recommend collecting approximately 100 data points for the accuracy measurement. First, while license plate matching is the most robust in terms of ensuring reliable and accurate ground truth measurements, it is costly for the amount of data that can be collected. Second, in order to measure variability, data needs to be collected at the same time over multiple days which would involve a lot of setting up and breaking down of equipment. For a single study, it makes the most sense to use video cameras with manual transcription (Toppen and Wunderlich 2003).

Real-time data collection for transit agencies consists mostly of transit vehicle location information. Use of Automated Vehicle Location (AVL) systems are common for large and medium sized transit agencies. In most cases, the transit agency receives the AVL data directly from transit vehicles through wireless communications links, but sometimes a third party collects the data and provides real-time location information to the agency (Technologies, Consensus systems; systematics, Cambridge technologies 2013).

Private-sector companies have developed significant efforts towards collecting and selling travel time information around the world. Companies such as Here, INRIX, and Google Maps have implemented quite impressive data collection systems that integrate both public and private data sources to predict travel times. These companies have started collecting the traffic information from the vehicle themselves by collaborating with many world class companies. The information are detected using vehicles, smartphones, cameras, and other sensors (INRIX 2014), (HERE 2014), (Barth 2009).

Traditional travel time prediction methods mainly assume a constant variance and predict point values for future traffic conditions. Since travel time changes significantly throughout the day, the point prediction method is less reliable and accurate when it deals with uncertain traffic conditions (FHWA n.d.). Different techniques for collecting travel time data in the field are described in the Travel Time Data Collection Handbook (Turner, et al. 1998). These techniques can be sorted into: methods that are based on probe vehicles, license plate matching, and up-to-date technologies such as cell phones tracking, Automatic Vehicle Identification (AVI) and inductive loop signature matching (Turner, et al. 1998).

In 2011, researchers compared travel times from GPS-equipped probe vehicles to traveler information system estimates from loop detectors. For evaluation of real-time traveler information system, this method can only collect a limited number of travel times during a time-interval; therefore, the limitation of sample size influences the statistical significance of the comparison for one day (Richardson and Smith 2012).

Bluetooth re-identification technologies have also had a notable impact on the ability of traveler information systems. Because so many travelers use Bluetooth devices in their vehicles, a significant sample size is available for measuring travel times along freeways and arterials. The emergence of this technology has enabled agencies to apply statistical sampling methods at very low costs; improving the confidence of the travel time these agencies estimate (Hainen, et al. 2011).

Recent travel time research has focused on the abilities of vehicles to communicate with each other and with roadside equipment. Vehicle communication with roadside infrastructure is termed vehicle-to-infrastructure (V2I) and communication between vehicles is termed vehicle-to-vehicle (V2V). These communication links can enable a plethora of abilities in future vehicles. One of the features of the V2I communication technology is probe vehicle data collection, in which vehicles collect information such as their location and speed. The speed information can be used for travel time estimation. A study found that microscopic data collected using V2I, provided reliable assessment of traffic conditions and prediction of travel time, with the use of an Artificial Intelligence-based algorithm, along a corridor (Ma, Chowdhuy, et al., Integrated Traffic and Communication Performance Evaluation of an Intelligent Vehicle Infrastructure Integration (VII) System for Online Travel-Time Prediction 2012), . (Ma, Chowdhury, et al. 2009)

Roadside equipment can be also used for estimating travel times in V2I communication environment. On this topic, researchers have developed methods for optimizing the placement of roadside infrastructure that communicates with passing vehicles in a V2I communication environment. This study has helped researchers make initial prediction of the number of roadside communication devices required for determining accurate travel times (Kianfar and Edara 2013). V2V and V2I communication will enable transportation agencies to efficiently manage traffic operation such as High Occupancy Toll (HOT) lane management by processing toll payment through in vehicle units (Misener, et al. 2010) or by providing dynamic lane usage instructions to drivers through on board units (Park 2008). However, selection of appropriate communication technologies for V2V and V2I for traveler information will be challenging. There are several competing technologies (e.g. DSRC, Wi-Fi. WiMAX, Cellular) that could be used for travelers information systems (Dar, et al. 2010).

Toll tags have also been a source of travel time monitoring information. A recent article reported the use of toll tags throughout New York, New Jersey, and Connecticut. This system, named TRANSMIT, monitors the traffic by reading E-Zpass toll tags on passing vehicles. Specifically, travel times and traffic conditions can be calculated by synthesizing the data from upstream and downstream road-side toll tag readers (Du 2014)

Vehicle to Infrastructure and Vehicle to Vehicle can be collectively termed “V2X.” Other research on V2X communication found that the traffic data collected and disseminated in such a system would provide great benefits to travelers, but the costs could reach $44 billion. V2X could help meeting several objectives that concern travel time data collection, including providing more accurate and timely road condition alerts and traveler information and reducing dependence on DOT traffic monitoring infrastructure (Hill and Garrett 2011). Such as dynamic routing of vehicles utilizing V2X infrastructures to provide real-time traveler information will help to reduce the incident recovery time (Bhavsar, et al. 2014). Active research on V2X is ongoing and has the potential to reshape the way travel time information is collected along the roadside and disseminated to travelers. Federal highway administration has developed National ITS architecture and Connected Vehicle Reference Implementation Architecture (CVRIA) to promote the research and development of V2X applications (FHWA, National ITS Architecture, Service packages n.d.) (FHWA, Connected Vehicle Reference Implementation Architecture, Aplication n.d.). CVRIA has identified three application areas for traveler information- i) advanced traveler information systems , ii) dynamic travel planning, and iii) Smart parking support information system (FHWA, Connected Vehicle Reference Implementation Architecture, Aplication n.d.). The National ITS architecture identified ten service packages to support different ITS applications for traveler information purposes (FHWA, National ITS Architecture, Service packages n.d.)

2-3 Previous Work on Construction Traveler Information

Information related to road or lane closure information which are caused by construction, are entered into the software systems manually by transportation agency personnel. A common challenge among transportation agencies is that the data entry is not done in a timely fashion, especially when there is a change to the construction plans for closing or opening lanes (Technologies, Consensus systems; systematics, Cambridge technologies 2013).

Smart work zone technology has been an important part of work zone management for quite some time. This technology provides travelers the real time information through websites or variable message signs, while on the route. Smart work zone technology not only helps to increase safety and provide travelers with delay and travel time information, but also the collection of historic and real-time traffic data can be used for both design and construction period (Jackson 2010). In the past years, several companies have developed and implemented smart work zone systems in different states such as Ohio and Wisconsin. A Traffic Information and Prediction System (TIPS), is a reliable system for predicting and displaying travel times. The information provided by TIPS, can be available in advance and throughout the work zones for the motorists. The provided information are all in real-time, portable, accurate and automatic; therefore, the system can be reliable from the mentioned aspects. TIPS collects the real-time traffic flow data using roadside non-contact sensors, and displays the information on portable, electronic changeable message signs positioned at pre-determined locations along the freeway to allow motorists to make decisions about staying on the freeway or taking an alternate route (Pant 2013).

2-4 Previous Work on Traffic Incident Information

Most transportation agencies have a network of closed-circuit television (CCTV) cameras monitored at a central facility, which are used to identify and classify incidents, which are then tracked in a software system. Another primary source of incident information is a data feed from the Computer Aided Dispatch (CAD) systems of public safety and law enforcement centers such as Public Safety Answering Point (PSAPs) (Technologies, Consensus systems; systematics, Cambridge technologies 2013).

In (Aerde and Yager 1990), the authors present the necessity to simulate both arterial streets as well as freeways when studying the effects of incidents. Among their findings are (RITA 2009) the benefits of route guidance increases with incident duration, (Chang 2004) for freeway incidents of 10-30 minute durations, dynamic route guidance reduced travel times 11-21%, and (Plaisant, et al. 1998) travel times could be reduced even further if arterial street signal timings could be coordinated with said route guidance.

In March 2009, Florida Department of Transportation released a report about Real-Time Route Diversion System (RTRDS). In this report, for real time traffic information and message dissemination, a modular design with interface to SunGuide was presented. Given an incident, finding efficient alternative routes with minimal operator input, RTRDS provides available real time and historical traffic data. The operator can use RTRDS to review and choose from alternate routes, which can be generated on demand or previously constructed (Hua 2009).

A micro-simulation suite called PARAMICS helps the traffic management center personnel make operational decisions by predicting future traffic conditions due to incidents. The output data of PARAMICS is based on drivers, pedestrians, and highway elements. The article discusses the impact of traffic incidents on two high crash rate segments located at South Carolina State using the PARAMICS traffic simulation software. The study concluded that, using the software was a good tool for real-time incident management to support decision (Fries, et al. 2007).

2-5 Previous Work on Weather Information for Travelers

Previous work on travel weather information has focused on two topics: environmental sensor stations and contracted weather services. Road weather data is collected from a network of environmental sensor stations. States that experience ice and snow use these sensors to gather atmospheric and pavement weather data. In some cases, private contractors collect the data and provide it to the transportation agencies for a fee (Technologies, Consensus systems; systematics, Cambridge technologies 2013).

The Clarus Initiative was established in 2004 by the U.S. Department of Transportation (USDOT), Federal Highway Administration (FHWA) Road Weather Management Program cooperatively with the ITS Joint Program Office. The initiative focused on creating a powerful aggregate data source with close to real-time atmospheric and pavement observations. This program collected data from a network of Environmental Sensor Stations (ESS) along freeways. Research has compared the data from these sensor stations, finding that they are as accurate (ITS Research Success Stories 2014).

The current use of RWIS by state DOTs is widespread (Rall 2010). According to 2009 data collection, at least 44 states and the District of Columbia reported using RWIS. Moreover, according to the reports, 33 state DOTs and three local transportation agencies were sharing RWIS data via the Clarus Initiative. A North American integrated weather observation and data management system, which collects and quality, checks road weather information and makes it available to all transportation users and operators (Rall 2010).

The New York City Department of Transportation has contracted the National Weather Service to use weather information from several weather instruments arrayed outside their office building. Some of the information used includes satellite imagery, local temperature, precipitation data and Doppler Radar information, one of the most advanced weather radar technologies in the world (National Weather Service New York, NY Tour Data Collection Page n.d., Doppler Radar Information and Definitions n.d.).

2-6 Dissemination of Traveler Information

The two primary purposes of real-time traveler information dissemination are: 1. Providing information directly to travelers so that they can make better travel decisions, 2. Providing information to other agencies and third party providers so that they can make better decisions operating and maintaining the transportation network (Technologies, Consensus systems; systematics, Cambridge technologies 2013). The new rule (23 CFR 511) does not specify any specific technique of disseminating information to the public. Note that information equity is defined by providing real-time information through at least two dissemination media, in both audio and visual formats to the travelers (TCRP 2013). The following subsections summarize previous research on common methods of disseminating real-time traveler information to the public.

In this thesis, the methods for disseminating the traveler information have been divided to three sections: 1. Current methods, such as, DMS, Web page, and 511 systems. 2. Emerging methods, such as, Smart-phone and social media. 3. Legacy methods, such as, Highway advisory radios.

2-6-1 Current Methods

In 2004 the Federal Highway Administration (FHWA) issued guidance to transportation agencies for displaying their travel-time information on dynamic message signs (DMS) (Paniati 2004).Weather related information, primarily where hazardous conditions can exist, is the primary output to travelers resulting from the collection of road weather data.

Providing the weather related information to the travelers should be via roadway devices (e.g., DMS, HAR, and Connected Vehicles) and through traveler information outlets (e.g., 511, websites, social media) (Technologies, Consensus systems; systematics, Cambridge technologies 2013).

511 in most states provide the real-time traffic information in all of limited access roadways and other major highways within the state, including congestion, crashes, construction, lane closure, road conditions and severe weather information (know before you go 2012)

2-6-2 Emerging Methods

Another way of providing the real-time traveler information to travelers is through websites and smartphones. In recent years, the use of dynamic web pages (dynamic web page is a web page that displays different content each time it's viewed), which don't require the personal computers to access has become popular (Robinson, et al. 2012).

2-6-2-1 Social Media. Especially social media, such as Twitter and Facebook are being used widely. The web pages usually contain travel-time data, average speed data, incidents that cause lane closures, and an expandable map of the region showing the traffic congestion. The social media mostly send short messages, which focuses on incidents, road closure, or hazardous weather conditions (Technologies, Consensus systems; systematics, Cambridge technologies 2013).

As reported by (Robinson, et al. 2012), agencies support the notion that new social media and technology need to be utilized. In the follow-up phone interview, agencies indicated that they have an app and/or Twitter account. Recently social media has been the most popular in some cases, but not necessarily the most effective (Robinson, et al. 2012).

2-6-2-2 Smart Phones. The University of South Florida has conducted a research on the dynamic travel information delivered to cell phones, which is called the TRACK-IT system. This method uses the real-time location and past travel history of individual users to provide highly-targeted and hyper-personalized alerts to their cell phones that are relevant to their real-time travel time along a route chosen by the user. The real-time traffic and public transportation information is integrated with the Path Prediction Technology with the use of Application Programming Interface (API). This project also illustrates a prototype for technology that delivers the information only when the traveler is traveling below the speed threshold or has stopped the vehicle. It can also speak to the travelers that use Text-To-Speech (TTS) APIs about the travel information, that they can get the information without checking their phone. Both "OD flow measurement and differentiated congestion pricing" were the two applications that are examined in the report (National Center for Transit Research 2011).

Both of the applications require tracking vehicles, thereby creating privacy concerns and potentially violating the "anonymity by design" principle. A novel secure OD flow measurement scheme that uses the properties of commutative one-way hash function for the driver's privacy has been proposed in this report (Zangui, et al. 2012).

Hawaii Department of Transportation (HIDOT) has launched "511 GOAKAMAI" by phone, which can upgrade website and mobile apps (DOT Launches 511 GoAkamai By Phone 2013). In this state, 511 is an interactive voice response system, which provides the real-time travel information and updates. Travelers can receive the current information on roadway delay and travel times, just by dialing 511. GoAkamai Mobile App for iPhone and Android, which has been released in August 2013, provides traffic congestion information, including travel times and images from more than 200 traffic cameras, 24/7. Figure 1 illustrates how the app is displayed on IOS phones. (DOT Launches 511 GoAkamai By Phone 2013).

Figure 1. Sample of GoAkamai app for IOS

2-6-3 Legacy Methods

Most of states use Highway Advisory Radio (HAR) transmitters at strategic locations along the roadway providing real-time information on traveler's car radio about traffic delays, emergency operations and construction updates, allowing the traveler to make informed travel decisions.

Highway advisory radio is considered the least effective dissemination technique; nevertheless 70 percent of the agencies use it and only 27 percent of them take it into account in their evaluation (Robinson, et al. 2012).

2-6-4 Traveler perceptions of Real-time Information

Many of the prior studies on real-time travel information have been based on user satisfaction. According to (Robinson, et al. 2012) almost 90 percent of agencies provide information on traffic conditions (e.g., roadway status, CCTV video, incidents, construction zones), and more than 65 percent don't provide alternate routes. Ninety eight percent of the agencies believe that traveler information enhances traveling experience; only 30 percent of agencies have conducted studies to demonstrate the benefits of TIS. According to the same report, 59 percent of the agencies indicated they provide traveler information because other agencies like them are doing it, perhaps it obvious that, 60 percent of the agencies do not feel they are more effective than others. The report mentions that the safety and transit alternatives information are the least important types of traveler information. The common comment of the agencies could be summarized as "there is never enough" and "we need more", when they were asked regarding to availability of funds and what can they do with the limited available funds.

Information sources that provide the major categories of data are as follows: 1. 511 phone system, 2. Electronic highway message signs, 3. Electronic local roadway sign, 4. Email and text message, 5. Highway advisory radio, 6. Mobile smartphones apps, 7. On board device, 8. Social media, 9. Websites (using laptops, desktops or mobile devices), and 10. Social media (Robinson, et al. 2012).

Travelers information source used for making the trip change decision prior to trip start, which was collected from the web survey data are mentioned in this part of the report. According to the agencies who responded to the web survey, television, radio, websites (not mobile devices) with 48.7%, 46.4% and 46.1% respectively have a strong role, where 511, email and social media are just used by few traveler. Another statistical report that has collected the travelers responses, illustrates the most common information sources used to make a trip change decision among the responded agencies while in transit, are radio, electronic highway messages and television with 54%, 32.5% and 26.5% respectively. Considerable factor that can be seen in the report is nearly one in four of the responders use information provided by television to make a trip change in route while in transit (Robinson, et al. 2012).

2-7 Key Findings of Other State Conformance Studies

Few publications detail the review of state conformance with this 23 CFR 511. One notable study reviewed traveler information activities the states in the northwest (NW) passage with respect to this regulation. The following sections provide a summary of the findings for each of the eight states that are in the northwest passage:

2-7-1 Idaho

Idaho provides real-time information to the public by using traveler information service. The Castle Rock Acquisition and Reporting System (CARS) provides traveler information to the 511 service in the state. The public information can be obtained by calling the 511 number or through the 511 website. In addition to the website, a condensed mobile version has been created to be easily viewed using a smartphone. All the construction information related to limited access roadways within the state are mostly reported by the district offices throughout the state, there are six offices that report these information. Construction information are entered to the system before the construction work starts, and if there are any changes in the schedule or rout the information would be updated immediately. State police and the statewide communication center which are located in Meridian, Idaho, are in charge of all the incident information throughout the state. In each section of the state, there are people in charge to inform the state communication center. The state communication center works 24/7, and it also prepares and sends the information to governor and FHWA offices. This center also provides road weather information for all roads and segments in the entire state. The state updates all provided information every 10 minutes on a 24/7 basis with an accuracy greater than 85 percent. Therefore, the state has met the rule and no additional improvements are required (Rafferty, Amegashitsi and Koster 2013).

2-7-2 Minnesota

Minnesota also reports real-time information by using CARS, which provides the information on the web, phone services, and XML data feed. The 511 system gathers the information related to metro areas from Twin Cities Regional Traffic Management Center (RTMC). Project engineers and construction personnel are responsible to report the construction information to Traffic Operations and Communications Centers (TOCC) before the construction projects begin and as any updates occur. Unplanned construction activities and incident information are managed by State Patrol dispatch. The process for inputting the incident information into 511 CARS not completely automated, which means the personnel should enter part of the information manually. The weather information that are reported by the RWIS sensors and dispatch reports, are manually inputted and updated every four hours, but if there are new weather conditions they would be updated at the time. Throughout the state the travel times are calculated using loop detectors, which most areas are covered. There are just few gaps on limited access highways. Travel times are processed through Minnesota Department of Transportation's Integrated Roadway Information System (IRIS) software, which is their Advanced Traffic Management System. Once the route of significance network is determined by the state, the existing coverage area will be compared. If it was found that sections of the network are not covered, additional loop detectors will need to be installed. All other coverage exceeds the minimum requirements for timeliness, accuracy and availability (Rafferty, Amegashitsi and Koster 2013).

2-7-3 Montana

Statewide information is distributed to Helena, Montana and is inputed to the Oracle database. The 511 website, phones and email services are linked to the Oracle database. The database includes construction, incidents, road weather information. After entering the data to the system the map is automatically updated. Construction project engineers that are in the division offices, are in charge of reporting the construction information on all limited access roadways. Weekly reports are supplied to headquarter in Helena by engineers, to be entered in to Oracle database. The incident information should be verified before reporting, by the field staff, after being called in by Highway Patrols and others. After observation of the state roads by the field staff the information is reported. The entire interstates network coverage is segmented on the map through ranges between one and twenty miles. All information is updated every 5 to 15 minutes and exceeds the minimum requirement for accuracy and availability (Rafferty, Amegashitsi and Koster 2013).

2-7-4 North Dakota

The North Dakota traffic operation center does not operate 24/7 year-round; in the winter months they don't operate at nights. Traveler information is updated by maintenance staff manually and/or remotely when outside business hours. Like Montana, the map application was developed and is maintained in-house, while the phone service is hosted by the consultant Meridian. The state has the technical systems in place, but they have high latency after office hours. To meet the minimum requirements for timeliness and availability, the state has suggested the possibility of working with partner agencies such as the Department of Emergency Services state radio, 911 Public Safety Answering Points and Highway Patrol. The construction information is reported and entered by field engineers, the information is updated automatically after being entered. Incident information are reported by Highway patrol throughout the interstates using media blast (fax or email) to inform the maintenance center. Field staff are responsible for covering road weather information. In addition, there are RWIS stations throughout the states that provide the information to the public and has visual information from the cameras installed in different sections (Rafferty, Amegashitsi and Koster 2013).

2-7-5 South Dakota

South Dakota utilizes IRIS software to input all of their information. Meridian prepares the interface for the 511 service. Real-time information is provided to the public by using web, 511 phone, apps, text, and emails. Currently there are no traffic operations centers in South Dakota, but there is an ongoing project which focuses on planning and 24/7 operation. The construction information are provided by office engineers in field throughout the state before the construction activity start. Only major incidents are reported to South Dakota Department of Transportation (SDDOT). Currently, incident information is entered into IRIS by the 12 field office located throughout the state. In field maintenance personnel are responsible for road weather information. During winter, at least three weather reports are sent each day. However, adverse weather conditions occurring over the nighttime hours may not be updated until the early morning hour due to the lack of a 24/7 traffic operation center (Rafferty, Amegashitsi and Koster 2013).

To meet the requirements for incident reporting, the state is considering training Highway Patrol dispatch officers to use IRIS. In time, another improvement might entail a data link between the Highway Patrol CAD system and operations staff. Weather condition reporting is also being addressed. Options being considered include creating a 24/7 operation center, partnerships other agencies and the use of automated systems (Rafferty, Amegashitsi and Koster 2013).

2-7-6 Washington

Washington State provides all the real-time information related to construction, incident, and weather in all the interstates. State Patrol CAD system and the Traffic Management Centers (TMC) provide the information. The traveler information is provided to the public, using by phone, web, apps, social media and email. Project engineers are responsible for reporting construction information before the start of construction project, and there are coordinators that provide updates weekly. The construction information is entered in ROAD reporting system, which provides the information for website, 511 system, media, and emails. Washington State Patrol, other police coordination and Washington Department of Transportation (WSDOT) are in charge of incident information, and they update the information if any incidents occur. WSDOT operates RWIS stations and uses the weather service forecast information for providing the road weather information. Washington State uses sensors to collect speed and occupancy data for providing travel time information. In the greater Seattle area travel times are provided to the public using a network of DMSs and web site. While travel time information is provided along the interstates and heavy commuter route, it cannot be determined if the rule is met until WSDOT establishes the route of significance network for the metro area. All other minimum requirements for timeliness, accuracy and availability are met in this state (Rafferty, Amegashitsi and Koster 2013).

2-7-7 Wisconsin

Wisconsin provides real-time information to the public by utilizing a 511 web and phone service. The information related to construction throughout the state are controlled by the Wisconsin Lane Closure System (WisLCS). All the planned and current activities related to construction which causes lane closure can be entered to the system immediately, because the system is real-time data based. Incident information are provide by Wisconsin State Patrol and Milwaukee County Sheriff. First the data are filtered then sent to State Travel Operations Center (STOC), where personnel review and make the information available to the public. The Wisconsin State Patrol is in charge of providing road weather information, the information are collected by field observations. Weather conditions are provided along all Interstates without having I-535 in count, because the length of the segment is less than a mile, and I-794 which runs through downtown Milwaukee. Additional coverage will be added along I-535 and I-794. Currently, travel time coverage in Milwaukee is lacking, like, some segments have in place speed, but are not available on the 511 map. Once the route of significance network is defined by the state, solutions to the problem will be addressed (Rafferty, Amegashitsi and Koster 2013).

2-7-8 Wyoming

Wyoming disseminates the real-information to the public by using websites, text messages, emails, and telephone. Similar to the other states evaluated, the 511 telephone service was provided through Meridian. The website will include construction, incident, and weather information. The construction information (surface conditions, delays, and lane closures) throughout the state are inputted to the system by field engineers. Construction information is reported to the Wyoming TMC in Cheyenne. TMC staff input the incident related information to the system. Incident information can be entered to the system more quickly, because the Highway Patrol is a part of Wyoming Department of Transportation. "DOT field staff, local agencies, police and public state government trained employees" report road weather information for segments throughout state. The information provided in online maps can be altered when necessary. Wyoming uses redundant systems, which allows information to be available 100 percent of the time and maintain a high accuracy (Rafferty, Amegashitsi and Koster 2013).

In summary, according to the previous studies in this field, most of the agencies collect real time data on freeways and major MSAs by using field equipment or purchasing data from private companies.

The travel times data have been detected using various methods such as, radar sensors, loop detectors, speed sensors, some new technologies are emerging such as, Bluetooth, microwaves for monitoring travel times. In peak hours for having a reliable data, license plate number matching has been a good replacement for loop detectors. It is worth mentioning that some agencies collect real time travel data using AVL from transit vehicles through wireless communication link.

As mentioned in this chapter construction related information are uploaded and entered to the system manually. Traffic incident information should be monitored or reported to the traffic management centers, so they can use appropriate simulation or software to come up with route diversion. Sensor stations and satellite imagery are mostly use to collect weather related data.

All the disseminating methods fall under three categories, current methods, emerging methods, and legacy methods. In most of the states, real time information are provided to the public through 511 system. Briefly, conformance studies usually found, little additional data collection was needed for agencies outside of metro areas and major highways.

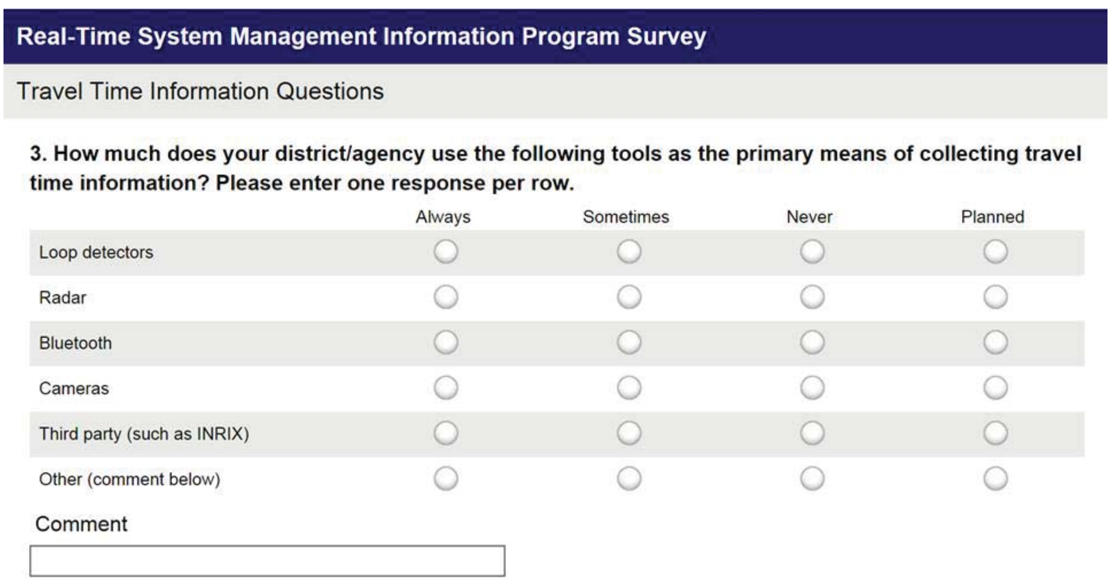
CHAPTER 3

METHODOLOGY

3-1 Survey Method

During this study, the researchers conducted an online survey to collect information about how State DOTs were planning on meeting Federal Regulation 23 CFR 511, to let IDOT be informed of the different state practices in United States. The survey was targeted at operational engineers and Intelligent Transportation Systems (ITS) coordinators, and associated FHWA District representatives in each state and was distributed via email. The respondents were chosen based on their knowledge and familiarity on state practices about real time traveler information. The survey was divided into five parts: travel time information (ten questions), construction information (five questions), traffic incident information (five questions), weather information (three questions), and demographic information about the survey respondents and their agencies (eight questions). The main purpose of the survey questions was to identify were different states are standing regarding the New Federal Regulation. How they are collecting the real time related information for travel time, construction, incident, and weather. After collecting these information, the tools that the states use for disseminating the information to the public. According to the new rule, the information provided to the public should be evaluated by considering the availability and the accuracy of the data; therefore, some questions were asked to help the researchers to identify various practices within different states to evaluate the disseminated information. A complete list of the survey questions can be found in Appendix B.

The survey was designed so that respondents were able to skip sections where they were unfamiliar. For example, a respondent may have intimate knowledge about travel time data collection and processing, but know little about how construction activities are reported. When respondents noted they were unfamiliar, the survey solicited contact information of a more-appropriate person and the research team followed-up with those listed. The questions were designed to allow multiple responses where appropriate, which means having a mutual exclusiveness in the answers. For example, some states have different methods for collecting travel time data, such as cameras, loop detectors and radars, so they were able to choose all of the answers that were applicable. Moreover, a space was provided in almost all questions, for the respondents to add their own answers. An example of the survey question has been illustrated in Figure 2


Real-Time System Management Information Program Survey

Travel Time Information Questions

3. How much does your district/agency use the following tools as the primary means of collecting travel time information? Please enter one response per row.

	Always	Sometimes	Never	Planned
Loop detectors				
Radar				
Bluetooth				
Cameras				
Third party (such as INRIX)				
Other (comment below)				

Comment

Figure 2. Survey question sample

A pilot study was conducted to ensure the clarity of survey questions and refine the design of response options, as recommended by Czaja and Blair (Czaja and Blair 2005). The pilot study included review by the research project's Technical Review Panel, two Civil

Engineering professors, and three practicing consulting engineers; all with expertise in this area.

After the survey was revised based on feedback from the pilot study, it was distributed to State DOT Operations Engineers, and State DOT ITS Coordinators, and to their FHWA representatives, who were active in the implementation in their agency's real-time systems management information program. These representatives were included from 50 states, the District of Columbia, and the territory of Puerto Rico. To analyze the data, standard statistical techniques were employed, such as confidence intervals. The student's t-distributions was selected because the number of respondents to any of the choices provided in the survey questions were not more than 30. The survey was distributed in June 2014 with two follow-up emails, and most responses were collected by mid-July 2014.

CHAPTER 4

ANALYSIS

4-1 Introduction

This chapter describes how researchers conducted an online survey to collect information from State DOTs and their FHWA representatives. This chapter has five different sections. In the first section, the survey questions and the analysis conducted on the responses received from different agencies about travel time have been covered. The next section talks about construction activities, which covers all the questions and responses received through the survey from different agencies. Incident information and weather information are the other two sections of the chapter, that analysis have been conducted on the received responses. The final section in this chapter is general information, which covers some information about the agencies and the individual respondents who took the survey. Some questions that has not been covered within the text has been mentioned in Appendix C.

The survey received a significant response, 67 percent, considering the short timeframe in which the answers were collected. This response indicates the importance and timeliness of their work towards this new federal rule. Overall 38 responses from 32 states/territories/districts were collected. Although there were no reasons provided by those states that did not respond to the survey, it is noteworthy that two of those states (California and Tennessee) were featured in a May 2014 webinar titled, "Innovative Approaches to Real-Time System Management Information" (US Department of Transportation 2014). Thus, it is possible that states that did not respond had already addressed their compliance practices related to 23CFR511. Figure 3 illustrates a map of the United States, where responding states are shaded.

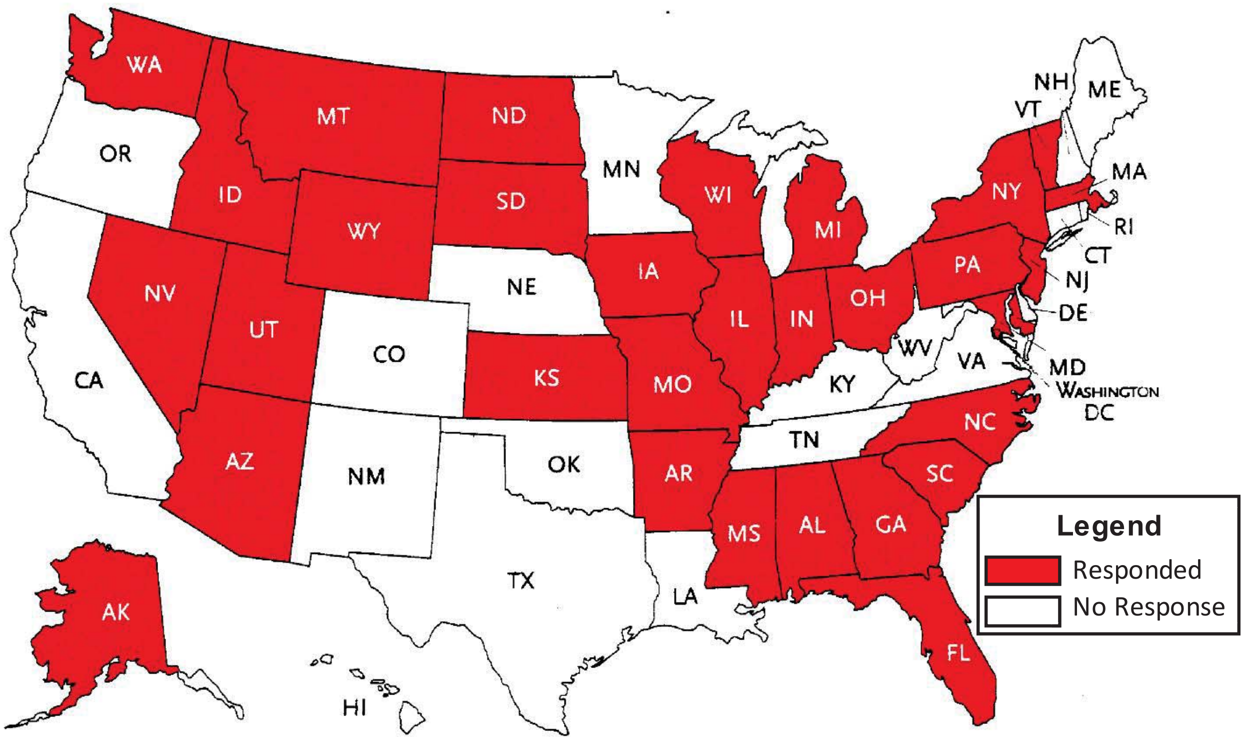


Figure 3. States/Districts Responding to the Survey

4-2 Travel Time Information

The first question within the travel time section asked, what tools were used for collecting travel time information and respondents were allowed to select all that applied. As shown in Figure 4, twenty three responding states indicated that they use third party data, among which fourteen said they always use this method and nine said they do sometimes. Note that the categories in Figure 4 were organized by the percent of respondents answering sometimes or always. The least used method according to the respondents was video surveillance, among which four said they always use this method and five said they do sometimes. Although a previous study (Martin 2007) noted the four common methods of measuring travel time, the findings did not present the frequency used in practice. These four methods included fixed detection of volumes such as loop detectors and radar, fixed detection of traffic speed, fixed detection using toll tags, and proprietary approaches such as communication monitoring. Different technologies are available today to collect speed and travel time data, such as Bluetooth sensors (Haghani, et al. 2010), vision-based license plate matching (Schoepflin and Daily 2003) and traffic detectors (Wang and Nihan 2000). These ITS-based technologies offer reliable and automated ways to collect travel time data. As mentioned previously, the tools for collecting travel time data have not changed significantly from the findings of a 2007 study.

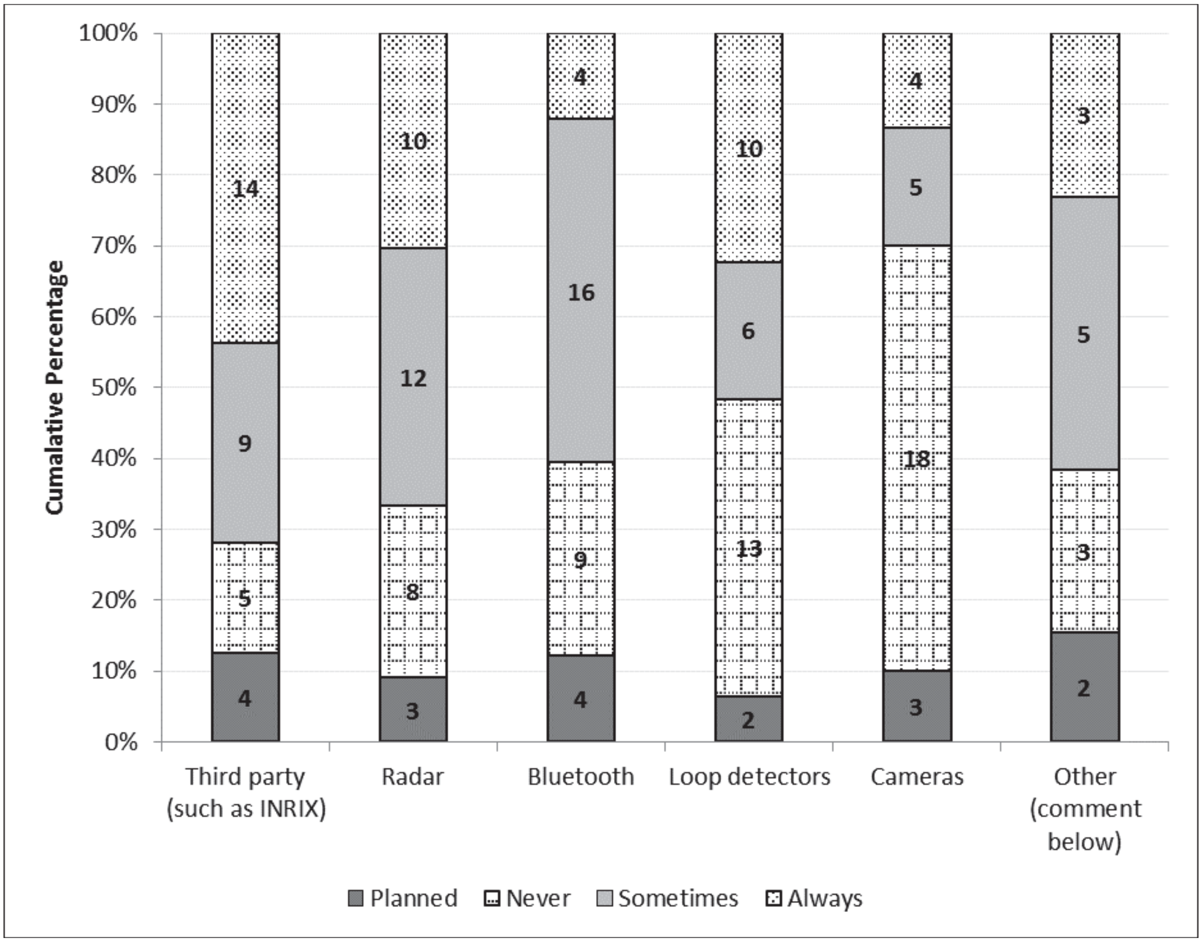


Figure 4. Responses to "How much does your district/agency use the following tools as the primary means of collecting travel time information?".

The second question in the travel time section asked how much their agency needed to expand their coverage of travel times within metropolitan areas (greater than 1,000,000 in population). In response, twenty one answered that their district or agency had already met the coverage requirements, twelve replied that their district or agency does not serve a metropolitan area and six replied that their district or agency should expand travel time coverage. Of those needing to expand travel time coverage, there was uncertainty about the magnitude of the expansion. According to the respondent's comments on this question (six comments), they were not exactly sure how much their agency needs to expand the travel time coverage and they were in the process of identifying the ROS at the time that they were taking the survey.

The third question asked, “How much does your district/agency process field data into travel times using each of the following tools?” Figure 5 illustrates the answers for this question. Note that the numbers inside each part of the bars represents the number of respondents choosing each option. Respondents were asked to choose “always”, “sometimes,” “never,” or “planned” for each method (shown as bars in Figure 5). The respondents were supposed to choose one of the four choices for each tool. As shown, the majority of respondents (70 percent always or sometimes) use third-party software to convert field data into travel time information. The next most-common response was software that was developed within their agency. Last, five reported that their agency sometimes or always used another method. Evaluation of the comments from these respondents revealed that they either used vendor software that was significantly modified in-hour, developed software with vendor/researcher assistance, or had purchased travel times that were already processed off-site.

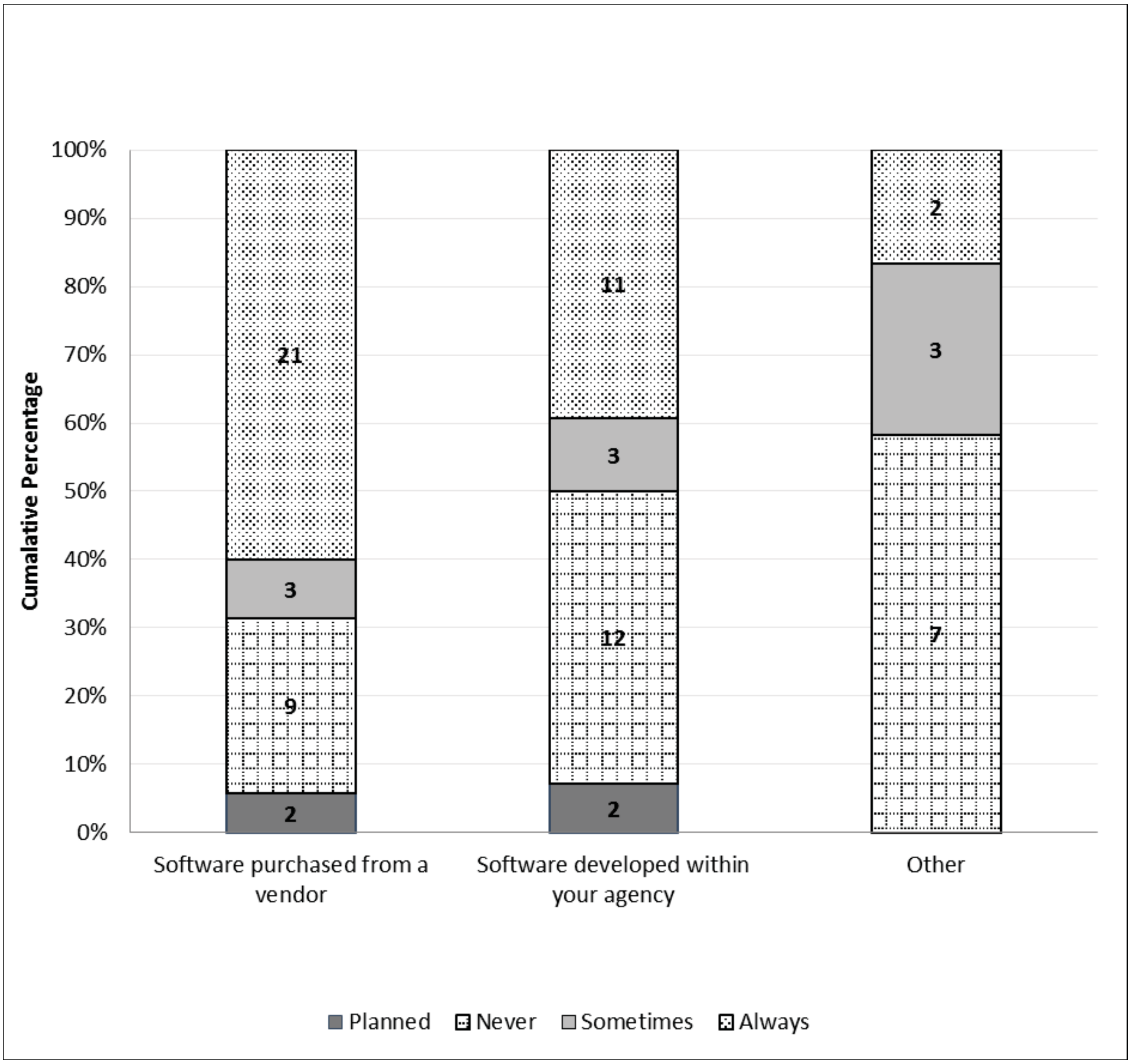


Figure 5. Responses to “How […] does your district/agency process field data into travel times…?”

The next question in the travel time section asked, “What guides or will guide your district’s/agency’s collection, processing, and dissemination of travel time data?” As shown in Figure 6, the most common answer with 20 responses, was that their agency/district had a standard practice but those practices were not formalized as either a guideline or a policy. The author consider a standard practice as less formalized than a guideline or policy; thus, many agencies lack a solidified structure for collecting, processing, and disseminating travel time data. Nineteen percent were not aware of anything that guided their travel time practices.

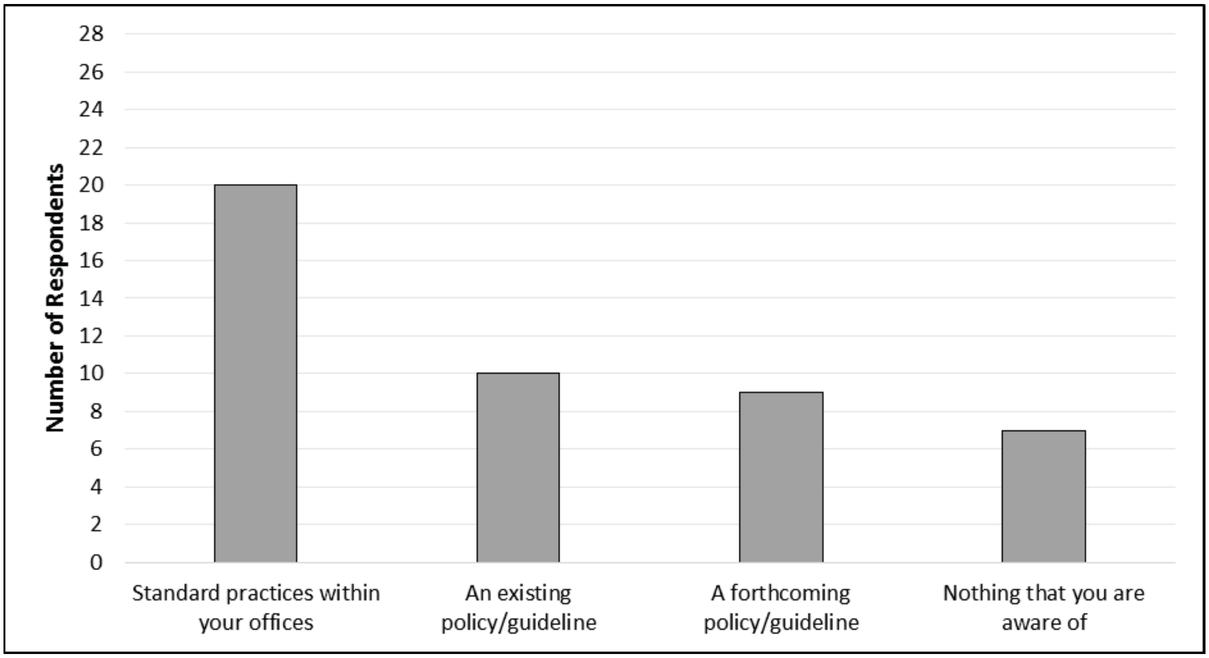


Figure 6. Responses to, "What guides or will guide your district's/agency's collection, processing, and dissemination of travel time data?"

The next question asked, "What is your district's/agency's standard practice for considering travel time information as 'accurate'?" There were total of nine choices that respondents could select from, including an array of different percentages, minutes, and also "Undefined" and "Other" (Figure 7). As shown in Figure 8, seventy five percent of the respondents considered travel time accuracy by using a threshold that was a percentage, twelve and half percent use both minutes and percentage, and again twelve and half percent used minutes. Note that in Figure 8, the number in the parentheses are number of respondents. Considering that, the New Rule requires travel time information be accurate within 15 percent, the agencies that were measuring the accuracy by minutes have to change their practices to a percentage. Figure 9, illustrates the number of agencies that responded to this question, which were using a percentage as their travel time accuracy measurement. As shown, most agencies selected accuracy thresholds of 15 percent or less which means they were in compliance with the new rule. Seven agencies selected "Undefined", meaning they did not provide travel times to their travelers. Note that some agencies selected more than one option; for example, one respondent could select within 10 percent and within one minute because they used different practices on different road segments. Altogether, there were six that said they consider accuracy within one or two minutes.

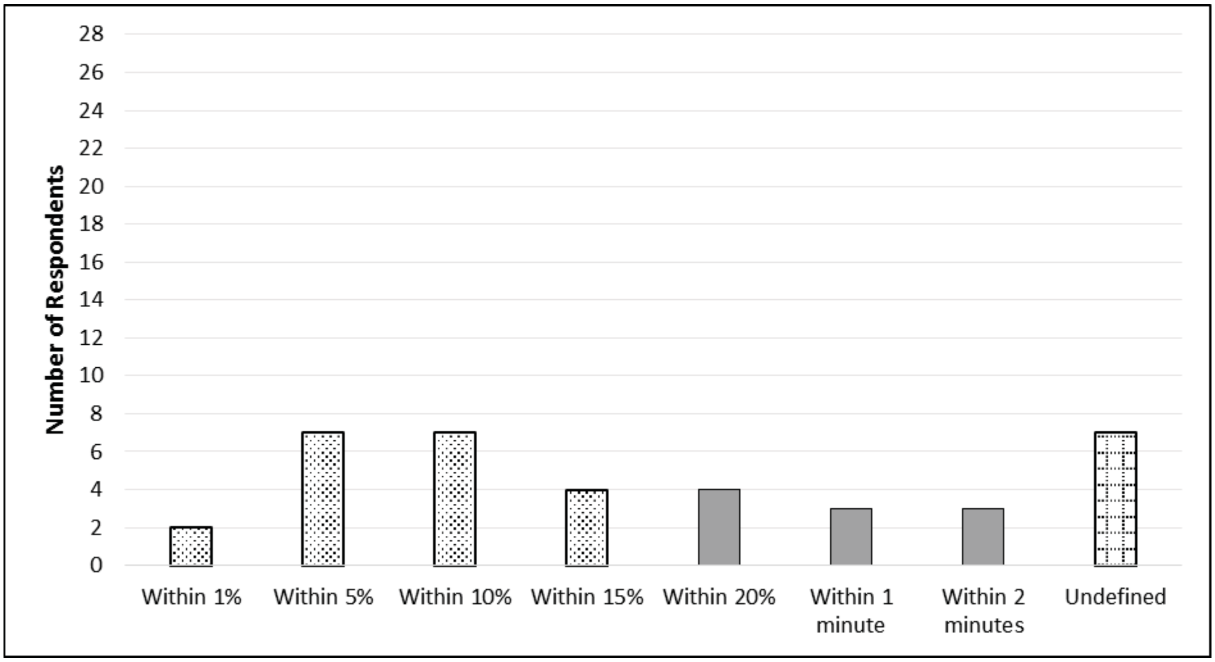


Figure 7. Responses to Question on Travel Time Accuracy Threshold

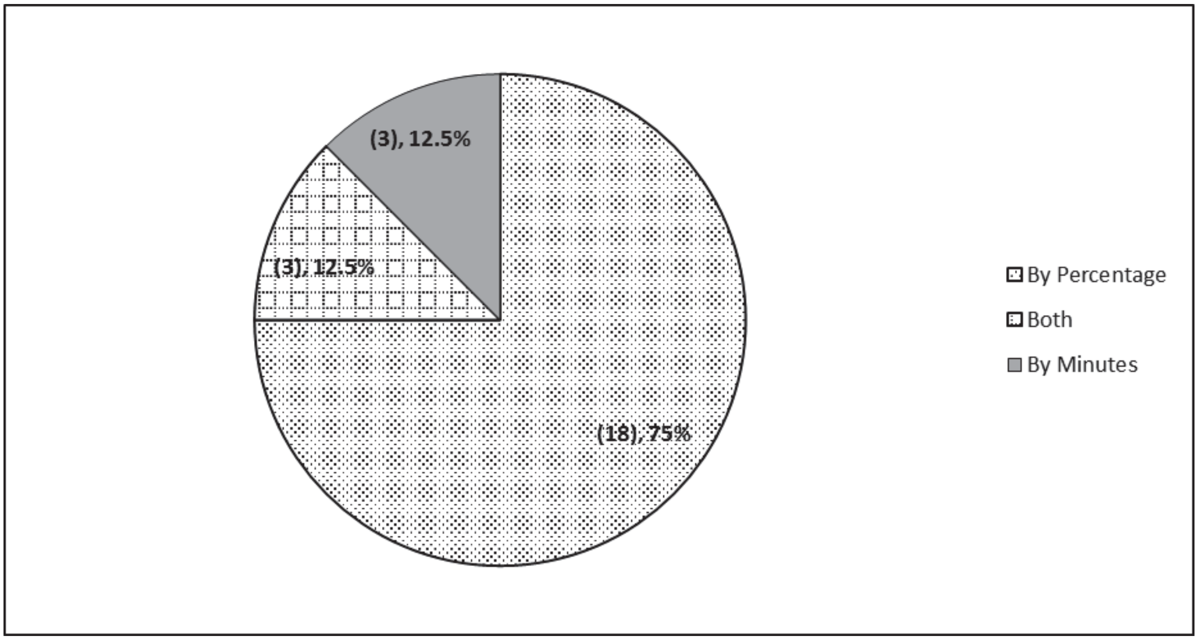


Figure 8. How Agencies Measure Travel Time Accuracy?

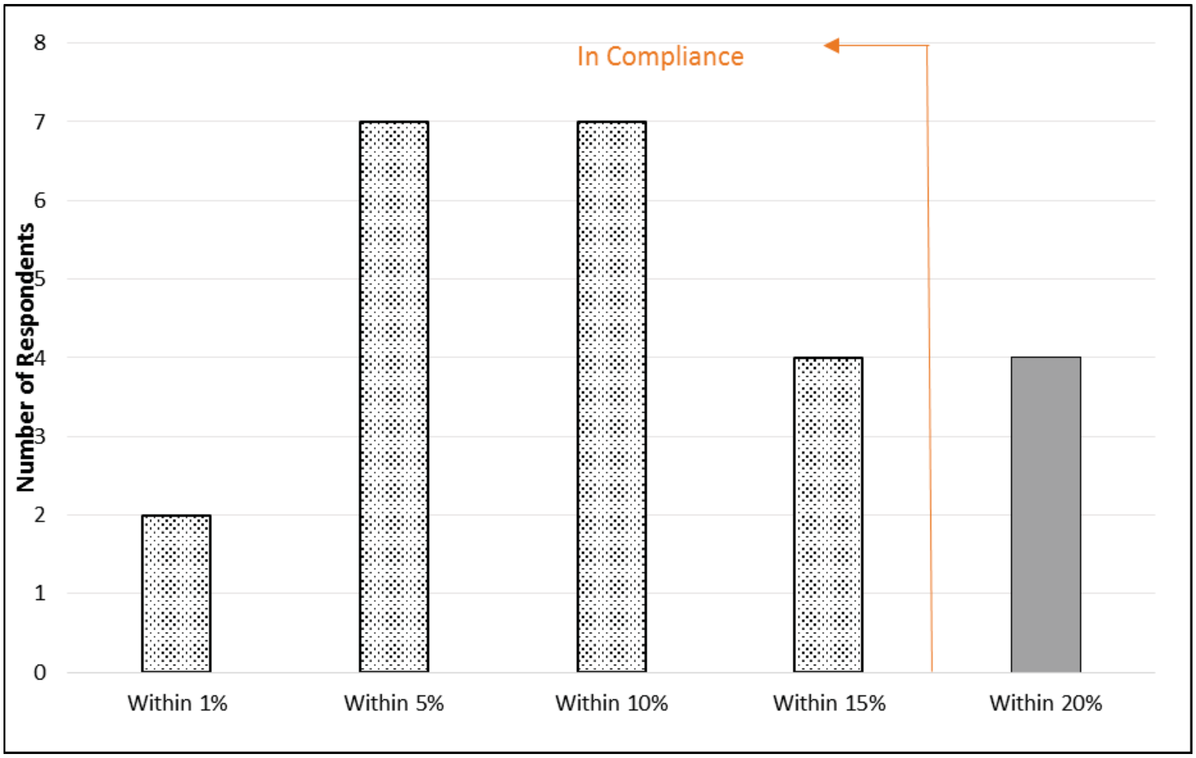


Figure 9. Agency Practices Measuring Travel Time with Percentage Accuracy

The next question asked, "How does your district/agency identify if a travel time is not accurate? Select all that apply." As illustrated in Figure 10, the two most common answers were "Expertise of personnel (employees intimately aware of average range of times at different traffic conditions)" and "Higher than normal calls or complaints from the public" with twenty six and seventeen responses, respectively. Several respondents (eighteen) selected "other," most of which (ten respondents) noted that their agencies did not have practices in place to identify inaccurate travel times. Overall, the responses to this question indicate that public transportation agencies are relying on non-technology-based methods for identifying if travel times are inaccurate. Only two of the responses indicated that technology was used to identify inaccurate travel times.

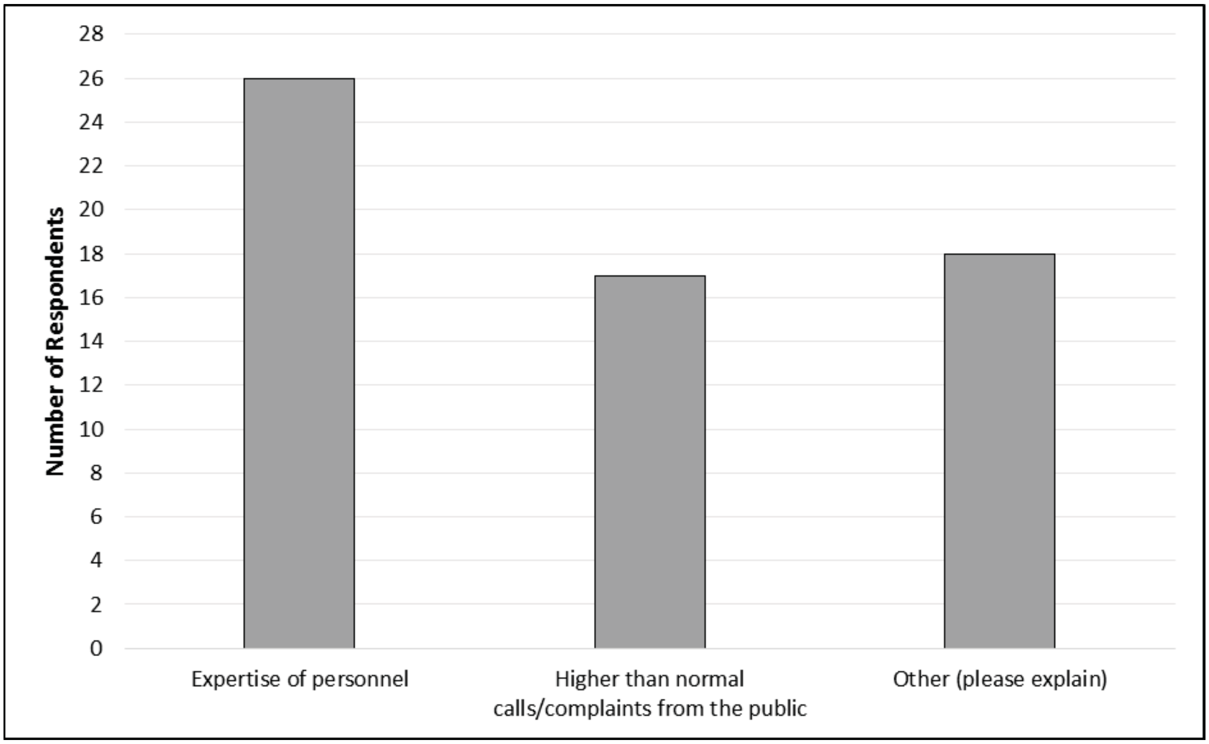


Figure 10. Responses to "How does your district/agency identify if a travel time is not accurate?"

The seventh question asked, "When you become aware that a travel time may not be accurate, how is travel time accuracy checked? Select all that apply." The three most common answers as illustrated in Figure 11, were "Field runs with a probe vehicle (such as a freeway service patrol)" with seventeen responses, "Cameras" with seven responses, and "Online sources such as Google Maps" with seven responses. The use of cameras and online sources were mutually exclusive; thus no agencies used both for checking travel time accuracy. Respondent comments on this question indicate that cameras were used to help identify traffic incidents and other sources of congestion that would create a change in travel times.

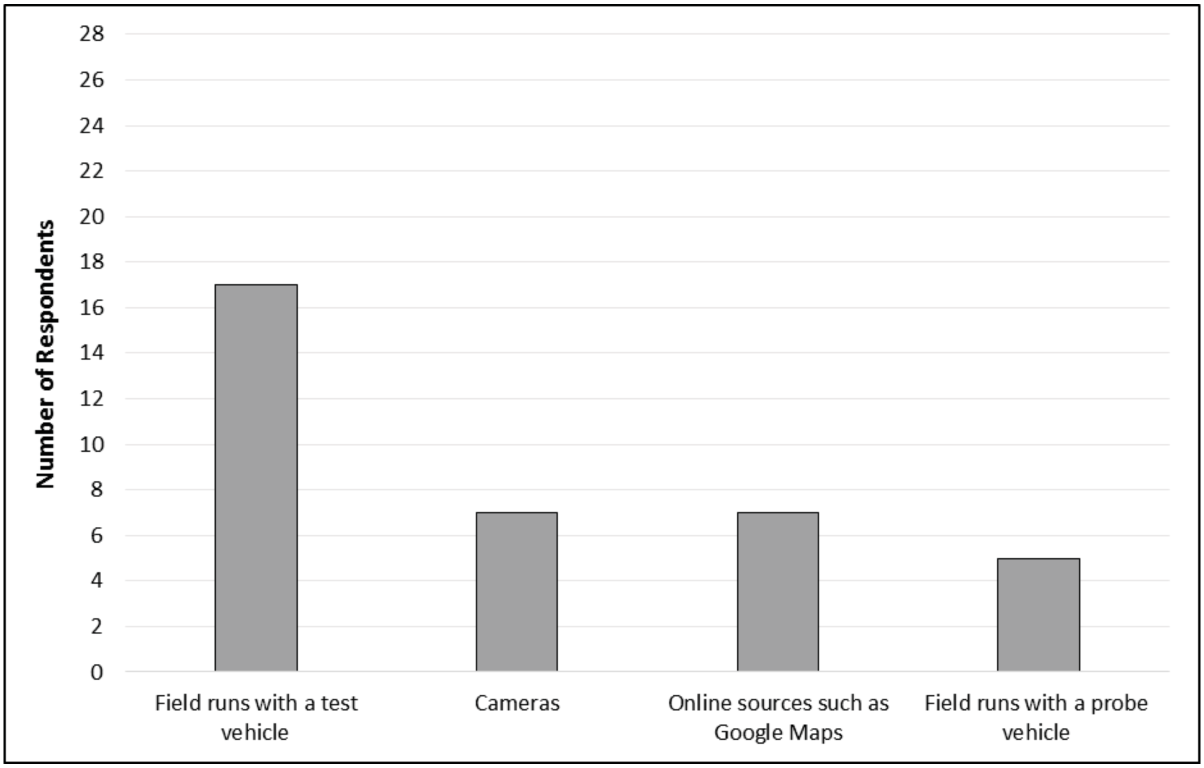


Figure 11. Responses to "When you become aware that a travel time may not be accurate, how is travel time accuracy checked?"

The next question asked, "If you collect travel times with probe vehicles, do you follow statistical sampling techniques?" Nineteen respondents answered "No" and only three answered "Yes". The states that indicated that they use these techniques explained that their data provider vendors use these methods. Additionally, private data providers are able to use agency data as well as data from other sources to verify travel time accuracy. Although multiple sources are available for practitioners to implement sampling techniques to ensure the validity of their travel time data (Veeregowda, Bharalo and Washington 2008), it appears that professional judgment currently plays a significant role in the data collection process.

The last question about travel time asked, "Please indicate which of the following are ways that the public can access your district's/agency's travel time information. Please enter one response [tool]". As illustrated in Figure 12, the most common way that state transportation agencies provide travel times to the public was using "Website" which twenty selected always and three selected sometimes. It is worth noting that forty five percent of the states, from the ones that have answered the survey questions use their state 511 website for disseminating real time traveler information to the public. After website, the common answers were "DMS", "511 system", "Apps" and "Portable DMS". Comparing these findings with previous work by (Crowson and Deeter 2013) indicates that no major traveler information dissemination shifts have taken place since 2012.

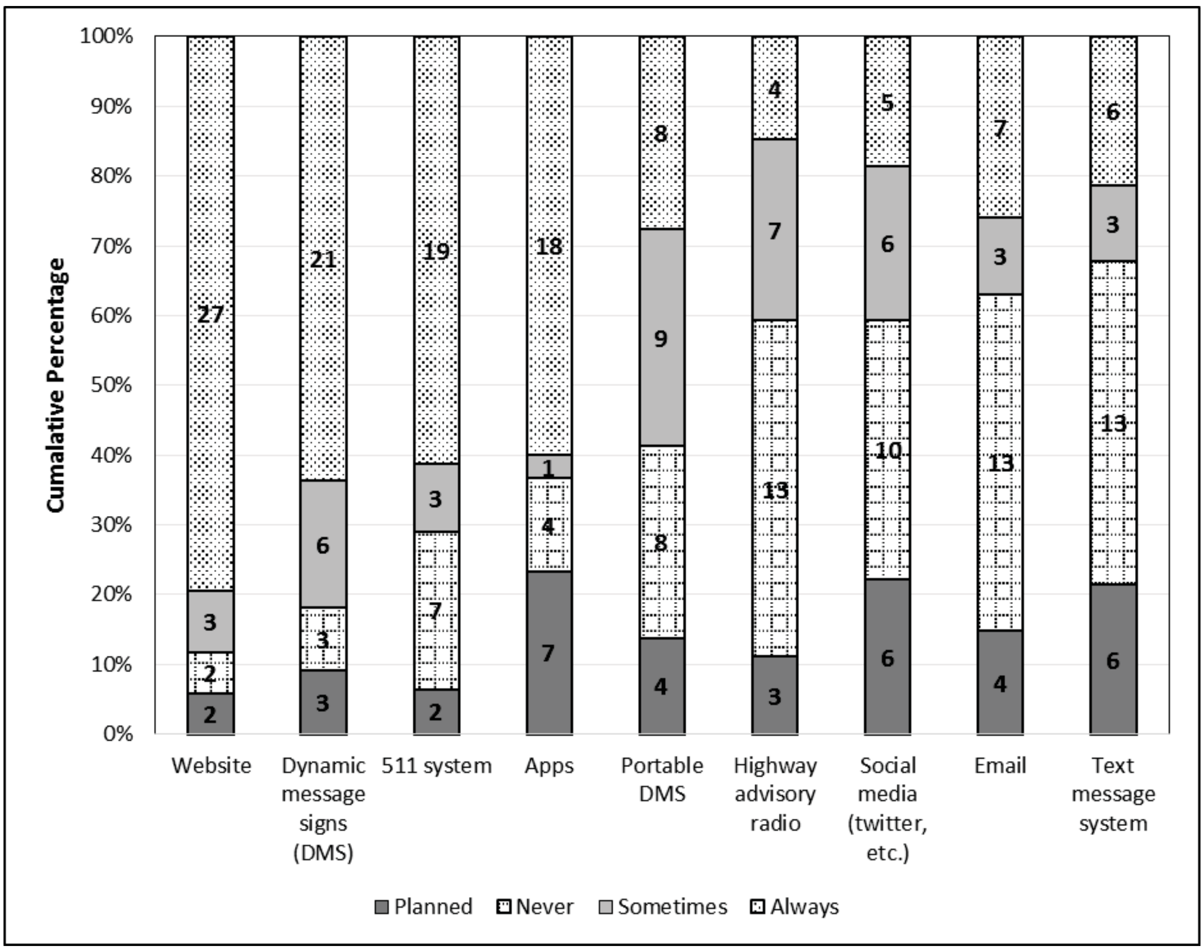


Figure 12. Ways that the public can access travel time information

4-3 Construction Information

The Illinois Department of Transportation Standard Specifications for Road and Bridge Construction are developed and adopted by the Department for improvements in road contracts. The Standard Specifications highlight the general requirements and covenants that can be used in different contracts. “Special provisions are additions, deletions, and/or revisions to the Standard Specifications” (Streets 2014). Note, if the requirements are not specified in an existing Special Provisions, it should be covered in plan general notes (Dion 2002).

The first question in the construction part of the survey asked “What methods are used to require contractors to provide real-time lane closure information?” As Illustrated in Figure 13, the most common answer for this question was “Existing specification” with sixteen respondents. The next common answers were “Existing special provisions”, “Existing general notes on plans”, and “Standard practices” with eight, seven and five respondents respectively. Surprisingly eight of the respondents for this question selected “None”, which indicates that they do not have any guidelines that require the contractor or staff to provide the real-time lane closure information.

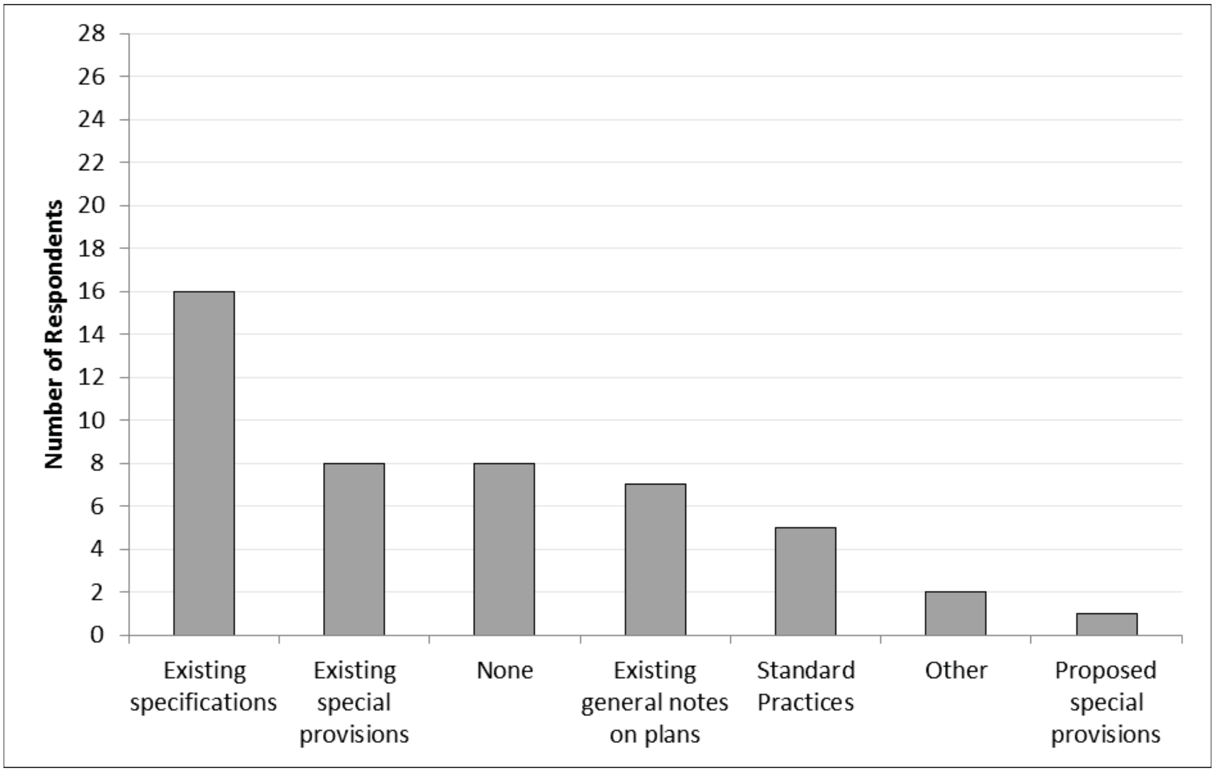


Figure 13. "What methods are used to require contractors to provide real-time lane closure information?"

The second question asked "How does your district/agency learn about real-time construction lane closures?" As shown in Figure 14 the answer that most agencies chose was "Contractors are required to inform our district/agency" with twenty two respondents which was sixty three percent of the survey takers. Twenty six percent of the respondents chose "We only know about planned lane closure" and the rest said that their own staff provides the real-time construction lane closure information.

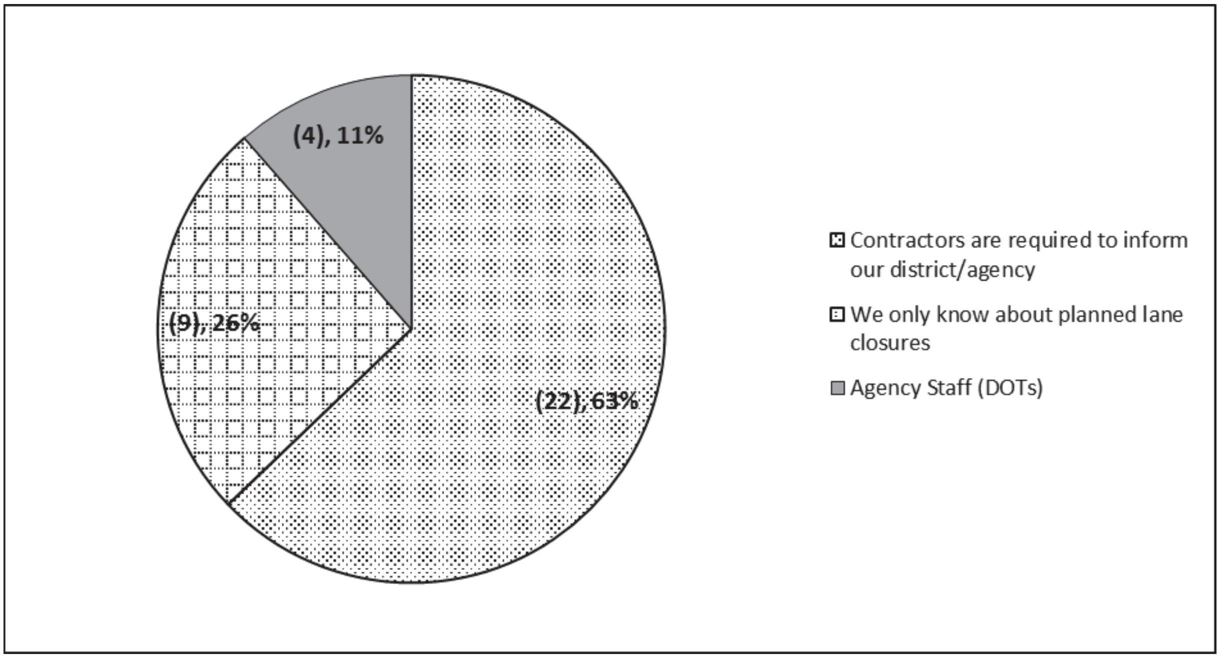


Figure 14. "How does your district/agency learn about real-time construction lane closures?"

The third question in the construction part asked "How does your district/agency provide construction lane closure information to the public?" Note that the numbers inside each part of the bars represents the number of respondents choosing each option. Respondents were asked to choose "always", "sometimes," "never," or "planned" for each method (see Figure 15). As shown, the majority (twenty nine respondents) chose "website". The other three common answers for this question were "Portable DMS", "DMS" and "511 System" with twenty eight, twenty seven and twenty four responses, respectively. The answers for this question were compared with the answers to the last question of the travel time section which asked about disseminating tools for travel time, four out of five common answers to these two questions were the same (Website, DMS, 511 System, and Apps). When the findings of this question were compared to previous studies (Crowson and Deeter 2013), there were no major changes in information disseminating methods. Where again "Website" had the lead in disseminating the information to the public.

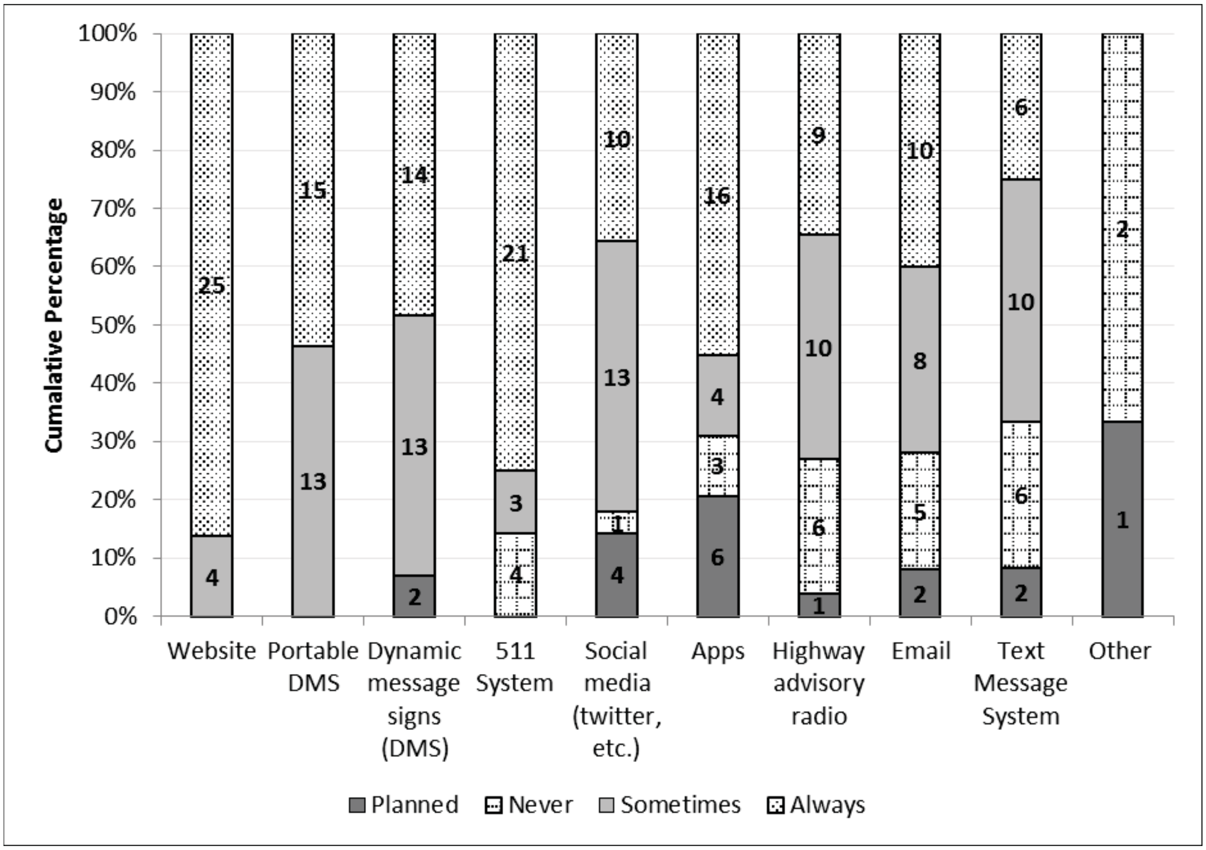


Figure 15. "How does your district/agency provide construction lane closure information to the public?"

4-4 Traffic Incidents Information

In the traffic incident part of the survey, the first question asked, "What requires law enforcement and emergency management services to notify your district/agency about traffic incidents (on limited access roadways) in real-time?" Figure 16 represents the respondents' answers for this question, where, "Existing policy/guidelines" was the most common response with twenty respondents. Eight respondents said, "Current standard practices" which requires them to notify their district or agency about traffic incidents. In the comment part of this question two respondents noted that practices change by the location of the incident.

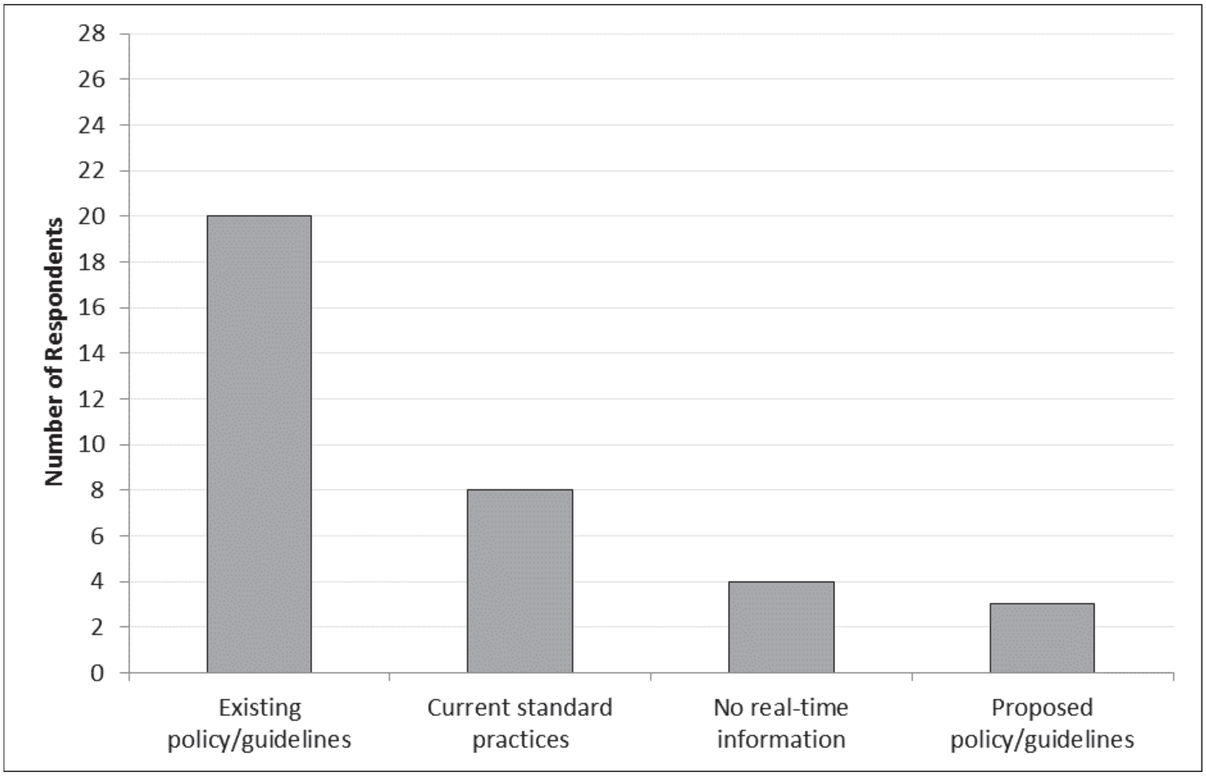


Figure 16. "What requires law enforcement and emergency management services to notify your district/agency about traffic incidents (on limited access roadways) in real-time?"

The second question asked "During normal business hours and after you are informed of a traffic incident, how quickly do you normally send this information to the public?" Average time of 31 respondents from different districts or agencies for providing the information to the public was 11.23 minutes.

According to the survey, the average time for providing the traffic incident information to the public outside normal business hour after being informed was approximately 44 minutes. This time is related to only five of the respondents, which their agency doesn't operate 24 hours a day. Several selected "other" in this question and in the comment part they noted that after-hour incidents are not always reported to the public.

The last question of the traffic incident part in the survey asked "How does your district/agency provide traffic incident information to the public?" The most common answer as shown in Figure 17 was "Website" with thirty one respondents, who use this method for disseminating the data "Always" or "Sometimes". The next common answers for this question were "Portable DMS", "DMS", "Social media" and "511 System" with thirty one, twenty nine, twenty seven and twenty six respondents respectively.

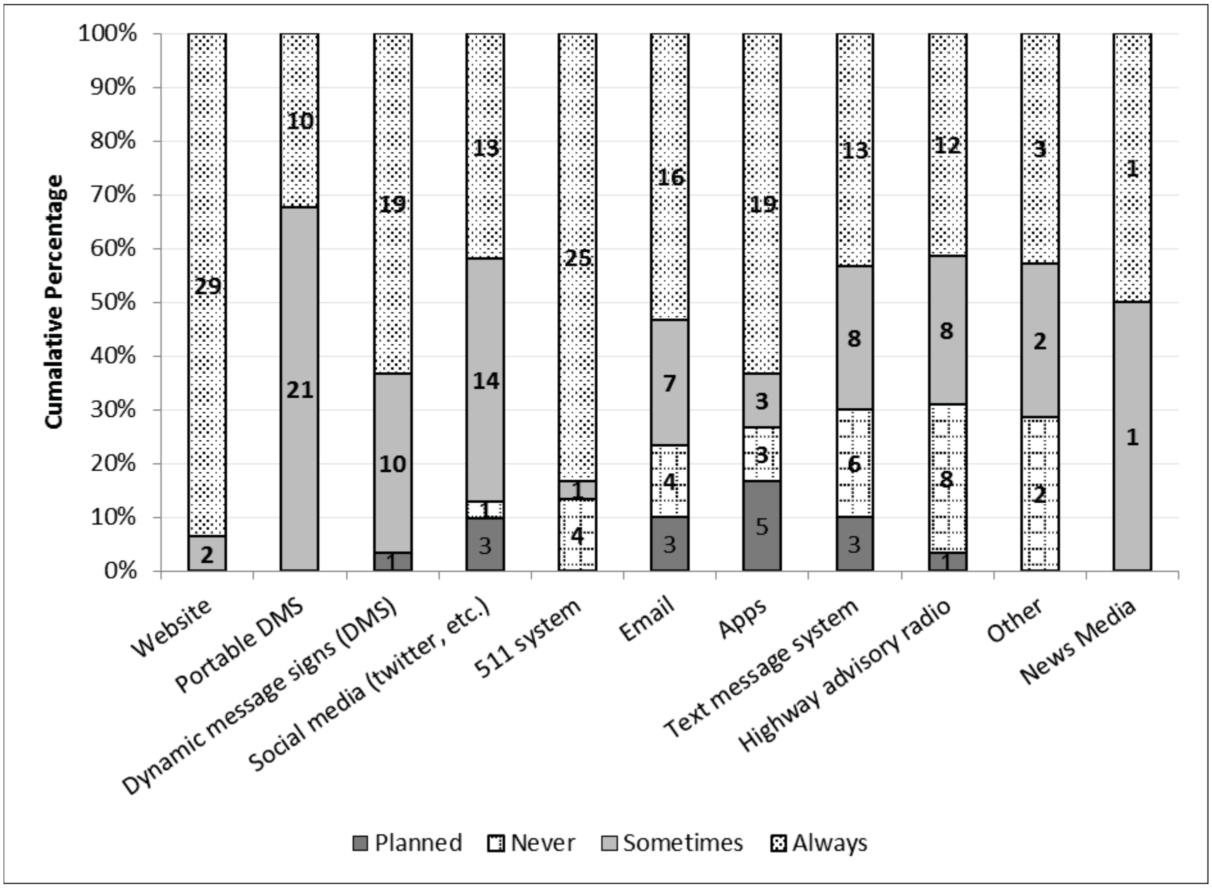


Figure 17. "How does your district/agency provide traffic incident information to the public?"

4-5 Weather Information

The first question in the weather section of the survey asked "How much does your district/agency use each of the following to collect weather information?" As shown in Figure 18, the majority, which was ninety seven percent of the respondents to this question, selected "RWIS" and ninety three percent selected "National Weather Service", only one respondent selected "Probe vehicles". There was one respondent that commented that they are going to convert the data from RWIS to MADIS (Meteorological Assimilation Data Ingest System) in future.

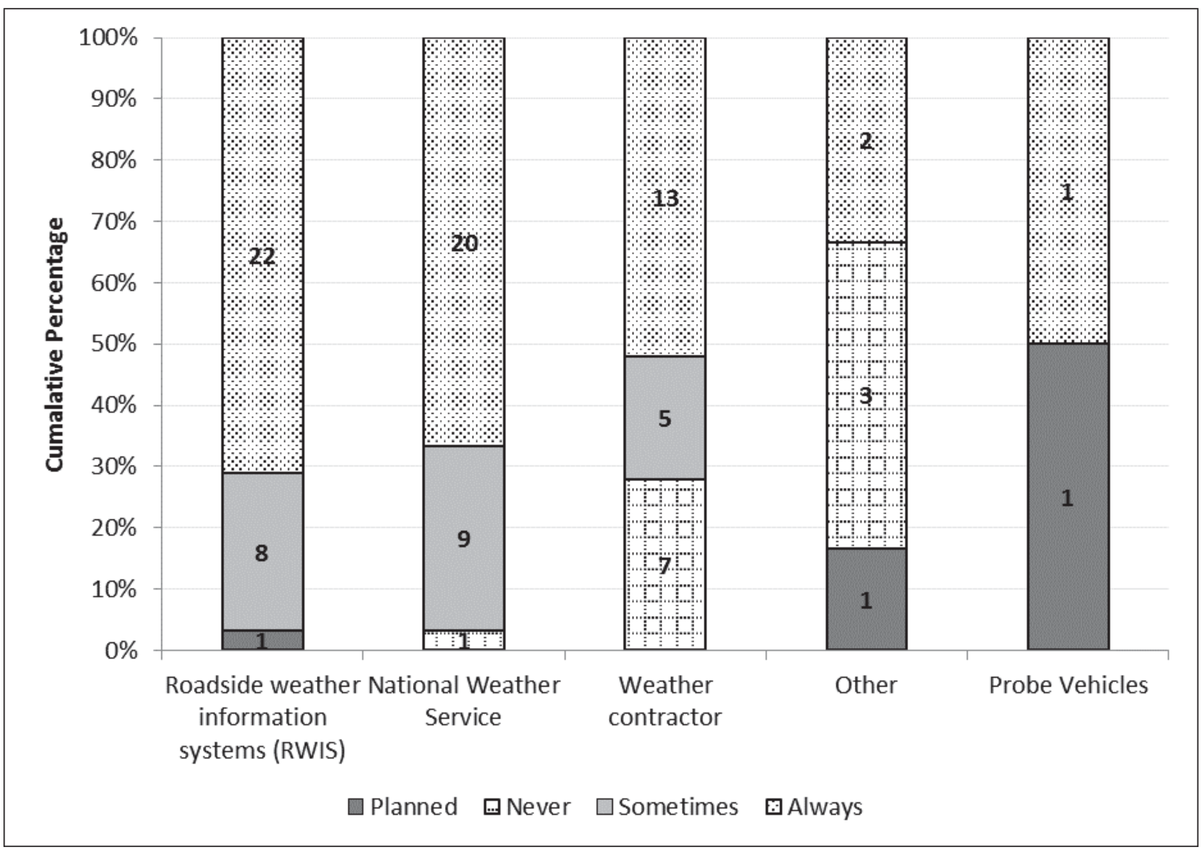


Figure 18. "How much does your district/agency use each of the following to collect weather information?"

The second question in the weather section asked “During severe weather events, how frequently does your district/agency receive information from field vehicles, such as snow plows, and other sources (select all that apply)?” As illustrated in Figure 19, surprisingly one of the two most common answers was “Calls from travelers” with twelve respondents. The other interesting finding from the survey was that three different agencies/districts responded, “No information from field vehicles”. Six of the respondents that selected “Electronic updates in real time” did not choose any of the “driver update” choices which indicates that either the information from the field vehicles are being updated automatically or they are not receiving any information from the field vehicles. The two respondents that chose “Your drivers provide updates upon request” selected all the driver updates that were under two hours (two, one, half, and quarter hour).

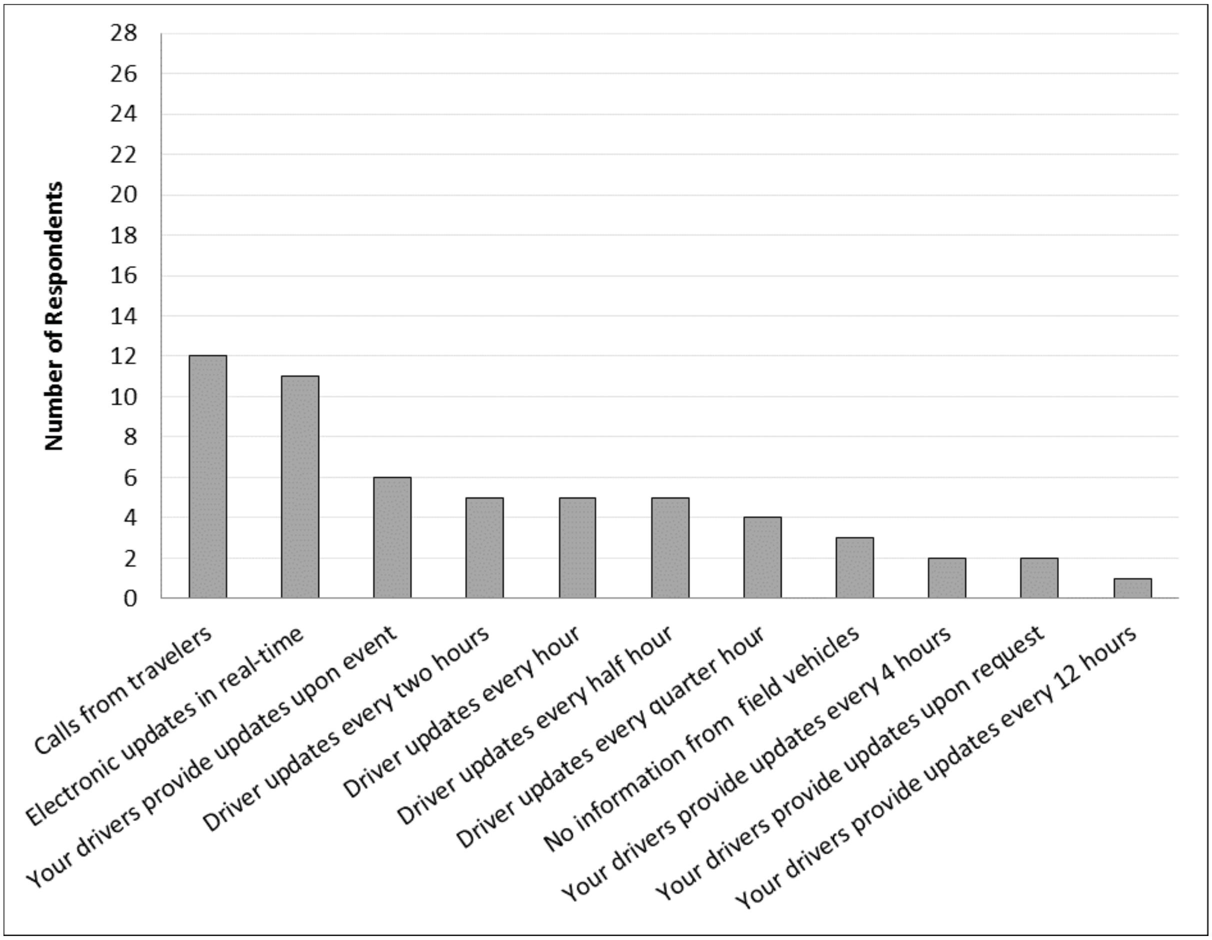


Figure 19. “During severe weather events, how frequently does your district/agency receive information from field vehicles, such as snow plows, and other sources?".

The final question in this section of the survey asked “How does your district/agency provide weather information to the public?” As shown in Figure 20, the majority of the respondents (twenty eight) selected “Website” for providing the weather information to the public. The other common answers for this question were “DMS”, “Social media”, “511 System”, and “Portable DMS”, with twenty five, twenty four, twenty four and twenty respondents respectively. If the answers to this question are compared to the similar questions in travel time section and construction section, it can be seen that again “Website” is the most common method for disseminating data within different agencies. “Email” and “Text message system” are two of the less common methods for providing information to the public.

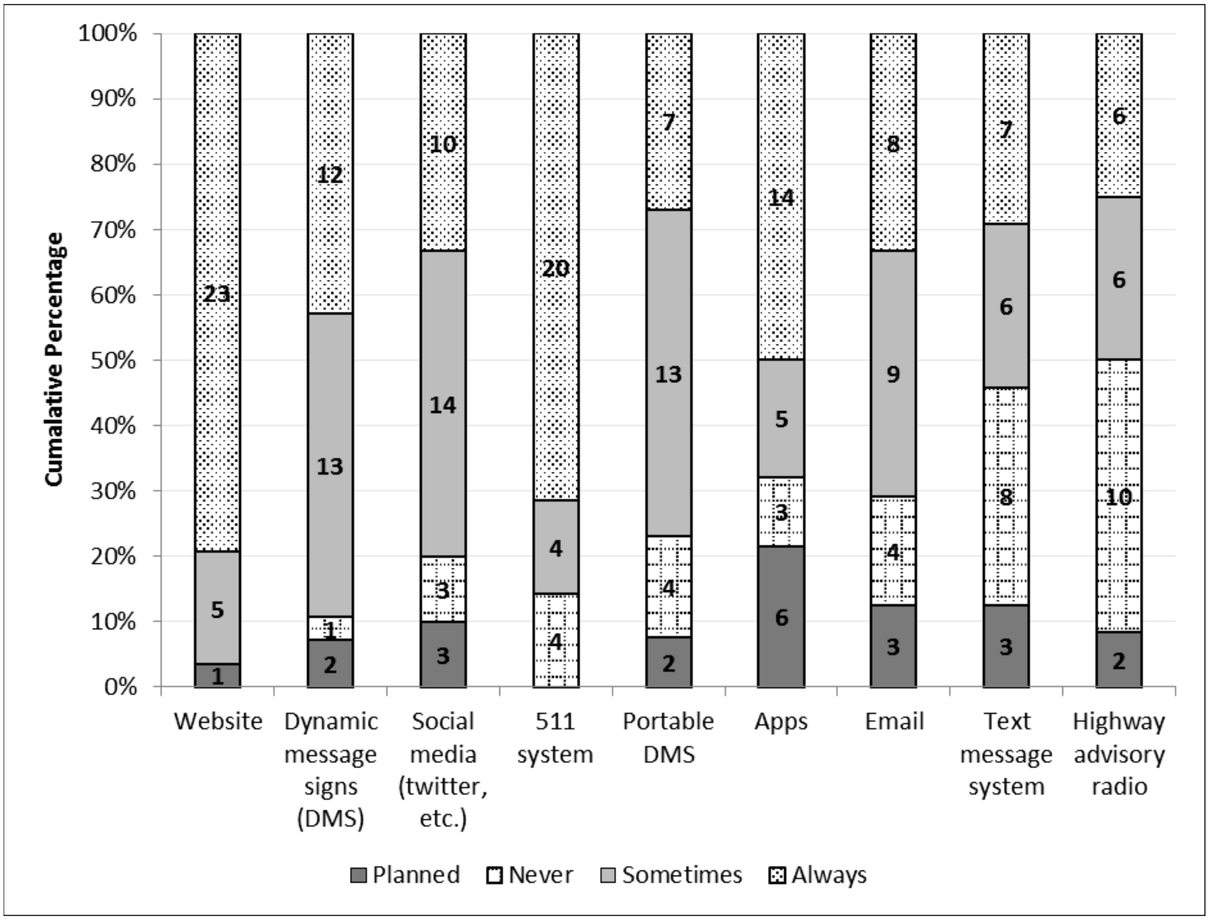


Figure 20. “How does your district/agency provide weather information to the public?”

4-6 General Information

The last part of the survey was titled “General Information” which asked general questions from the respondents. The first question asked “What agency do you represent?” States that are shaded in red answered the survey as shown in Figure 3.

The next question asked, “How much do you agree with the following statement. I am familiar with the new Federal Real-Time Systems Management Information Program requirements?" Which, ninety percent of the respondents strongly agreed or agreed with the statement.

The other question in the "General Information" part asked "In your opinion, how much do you agree that each of the following has prepared your transportation agency for the inter-agency communications needs of the new Real-time Systems Management Information Program requirements?" As illustrated in Figure 21, the majority of the respondents agreed or strongly agreed that "Following a state Intelligent Transportation Systems (ITS) architecture", "Following a regional ITS architecture," , "Other inter-agency training" , "Emergency management training exercise", and "NIMS training" has prepared their agency for these communication needs.

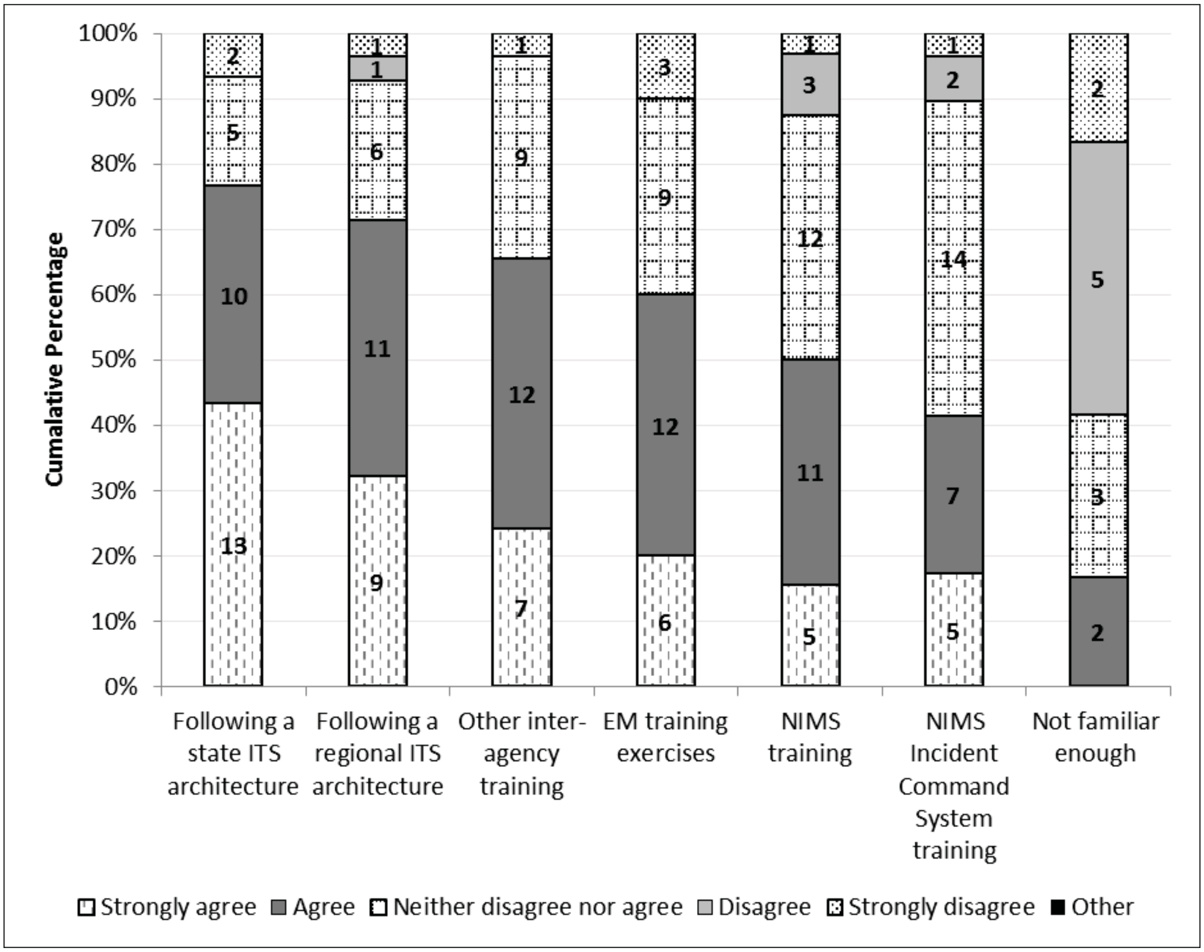


Figure 21. "In your opinion, how much do you agree that each of the following has prepared your transportation agency for the inter-agency communications needs of the new RTSMIP?"

The next question asked, "Please characterize the population density of the travelers you serve in your coverage area". The respondents could have selected Urban, Suburban, Rural and all. Figure 22 shows the responds for this question in more detail. As illustrated, nineteen selected "All" and six selected "Only Rural", where, two selected "Urban and Suburban" and only one selected "Suburban and Rural".

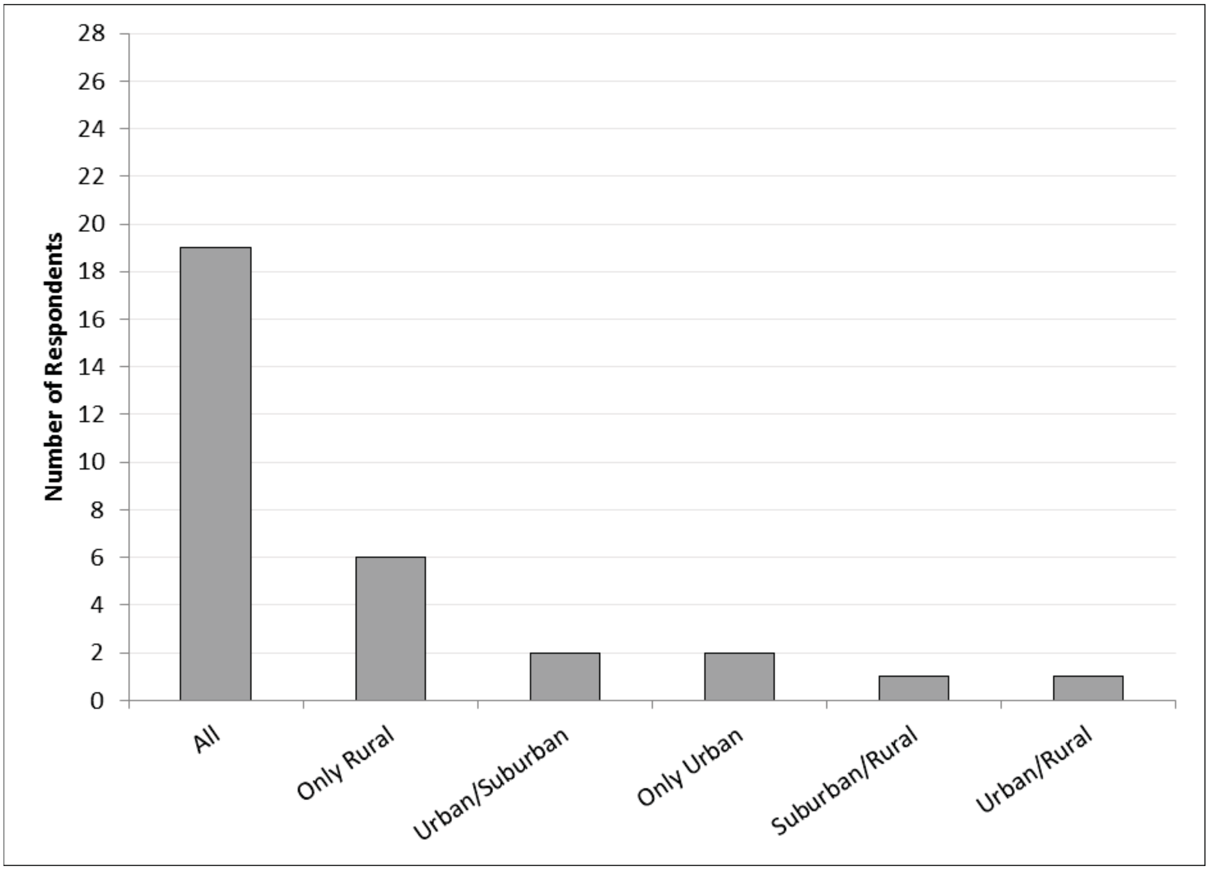


Figure 22. "Characterize the population density of the travelers you serve in your coverage area".

Another question in the "General Information" section asked, "What is the most challenging aspect of meeting the spirit of the new Federal Real-time Systems Management Information Program requirements?", because the answer for this question was open ended; therefore, a text analysis was conducted. Note that the answers for this question were mutual exclusive; therefore, the answers for each respondent could not be counted in more than one category. As shown in Figure 23, the answers were divided into 7 sections. Twenty seven percent of the respondents to this question, mentioned meeting the accuracy requirements, is the challenging aspect of meeting the new Rule. The new Rule requires the states to provide the real time information to the public with at least 85 percent accuracy. All the data received from the DOTs should be archived, and be compared with the information which is disseminated to the public throughout the year, to observe the accuracy.

Next, sixteen percent of the respondents answered "Arterial travel times" were among the most challenging. Providing the travel time for the travelers on arterial routes with limited access, is the second phase of the rule which State DOTs have to meet by November 8, 2016. Because these routes are not always monitored, calculating the travel times can require additional infrastructure deployment. "Funding needed changes" was the next category that sixteen percent of the respondents had answered. Respondents mentioned having the right technology to collect and distribute the information, and appropriate ATMS systems, needs specialized funding. There are also some areas that still need to build out their traffic data collection systems, but it is difficult with competing funding priorities. "Unclear rule details" and "Meeting availability requirements" were noted by three respondents each. As comments for this question indicated, some states were already meeting the new Regulation requirements, but because of lack of clarity, they were not sure what exactly they needed to show for compliance. Procurement mechanisms and agreements for data sharing between agencies (public and private), have been another challenging aspect for the agencies to meet the new Rule; therefore, two of the respondents answered "Data sharing and procurement mechanisms". Because the survey was collected in July, DOTs only had four months remaining to meet the requirements at the time of their response; therefore, three of the respondents answered "Limited deployment time".

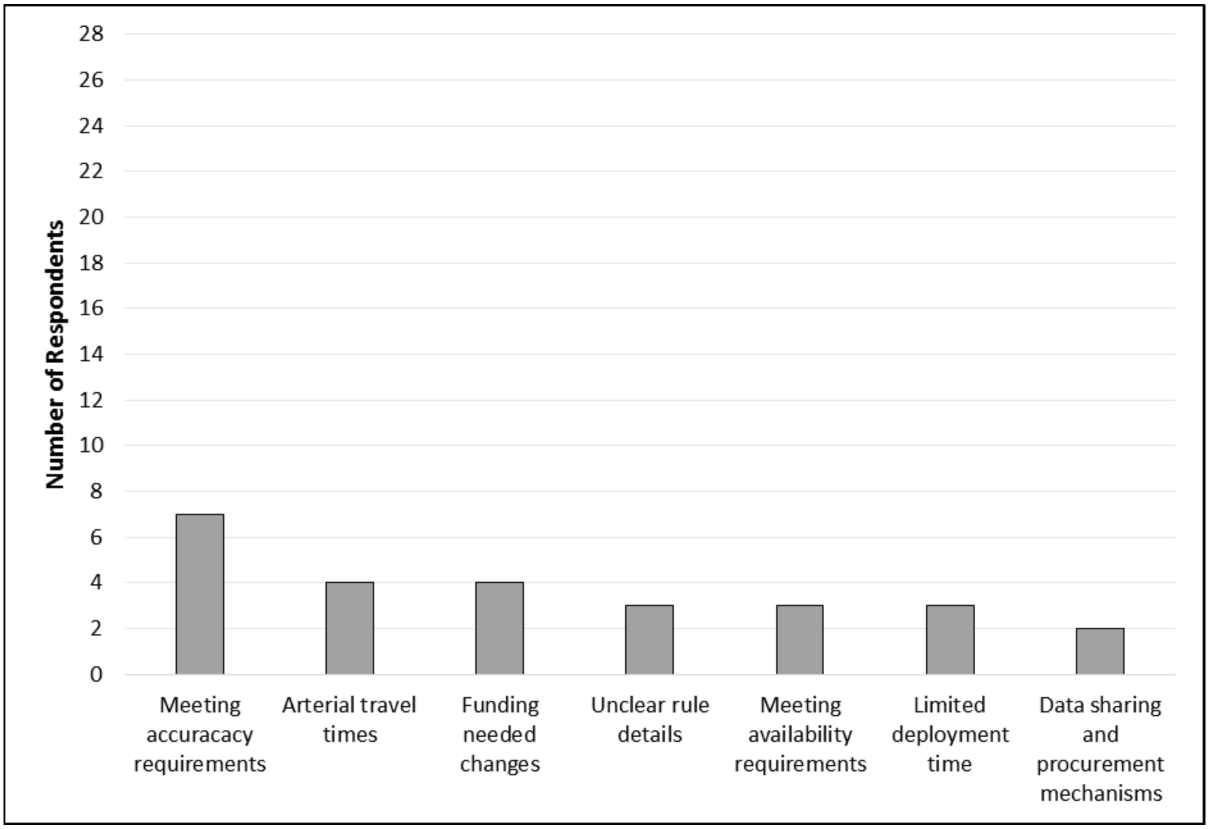


Figure 23. "What is the most challenging aspect of meeting the spirit of the new Federal Real-time Systems Management Information Program requirements?"

According to the survey, eleven of the respondents represented Federal Highway Administration (FHWA), and rest of the respondents which were twenty-four, were from state DOTs. Because ninety percent of the survey respondents indicate that they were familiar with the new Federal Real-Time Systems Management Information Program requirements; therefore, the findings of this research can aid engineers and practtitiioners in the related area for further studies.

CHAPTER 5

CONCLUSIONS

This chapter reviews the key thesis findings and draws conclusions. This study has contributed an updated compilation of state DOT activities towards establishing their real-time systems management information programs per Federal Rule 23 CFR 511. The key findings indicate that technologies used for collecting of travel times continue to evolve. The processing of field data into useable travel times is most frequently done with vendor software, with a large contingent using in-house created software. When disseminating travel times to the public, the proportion of different technologies has changed little in the past few years. Findings also indicate that a majority of agencies already meet or exceed the accuracy thresholds required by the new rule.

The survey responses indicated room for improvement with respect to identifying inaccurate travel time predictions and using statistics to support travel time sampling. Currently, the expertise of traffic management center personnel and calls from the public are the two most common ways that agencies identify if travel time estimates are inaccurate. Agencies that reported having no procedures for reviewing the accuracy of travel times after a system was in-place to collect and disseminate travel time data, will need to establish such a procedure as part of their real-time systems management information program to meet 23 CFR 511.

Transportation agencies that used probe vehicles to check the accuracy of travel times reported limited use of statistical techniques. Unfortunately, without applying statistics, practitioners may not collect an adequate sample size and might therefore inaccurately estimate travel time. Agencies should incorporate statistical sampling techniques and sample size criteria for measuring travel times.

According to the survey responses, real-time lane closure information related to construction activities are mostly provided by contractors that are doing the construction works. Within agencies, they are specifications, special provisions, general notes, or even practices that has become common, that requires contractors to provide the lane closure information to the agency. Still there are few agencies, that do not have any special requirements for contractors, and agency staff are in charge of reporting the construction information.

Survey results indicate that the majority of the agencies have an existing policy, guideline, or standard practices within their agencies that require law enforcement and emergency management agencies to inform transportation agencies of any traffic incidents that caused lane closures on limited access roadways. It is worth mentioning that all the agencies that responded the survey disseminate traffic incident information to the public during normal business hours. The survey responses indicated room for improvement for providing the incident information to the public outside normal business hours.

The agencies collected road weather information mostly by RWIS and National Weather Service, according to the received responses to the survey. Collecting the weather information using probe vehicles is not common method. Findings indicated that during the severe weather most of the agencies rely on traveler's calls as well as their field vehicle drivers updates.

Inter-agency communication preparation within different agencies to meet the new Rule differ, but the majority of the agencies refer to state ITS architecture, or regional architecture, where some states have their own inter-agency training. According to the survey respondents, majority of the agencies coverage area had rural, urban, and suburban.

The new rule has different aspects that agencies have to consider to comply with the Rule; therefore, according to the survey responses the most challenging aspects of the New Federal Rule for the agencies are accuracy requirements, collecting and reporting travel time in arterial roads, and the allocated budget and funding for the agencies.

Overall, the findings of this study can aid both practitioners and researchers. Transportation engineering and planning practitioners can use the findings of this research to continue refining State DOT practices for traveler information. These findings can also provide practitioners with a perspective of how other agencies are measuring the quality of their real time information.

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APPENDIX A

MILES OF INTERSTATES AND ROUTES OF SIGNIFICANCE

Table A 1. Miles of Interstates and Routes of Significance (FHWA, National Highway System 2013)

State/ Territory	Total miles	Metro Area >1 Million
Alabama	998.77	Y
Alaska	1082.22	N
Arizona	1168.64	Y
Arkansas	647.32	Y
California	2455.74	Y
Colorado	952.91	Y
Connecticut	346.17	Y
Delaware/Maryland	40.61	Y
Florida	1497.58	Y
Georgia	1243.98	Y
Hawaii	54.91	N
Idaho	611.76	N
Illinois	2182.03	Y
Indiana	1258.57	Y
Iowa	781.24	N
Kansas	874.34	Y
Kentucky	800.4	Y
Louisiana	902.84	Y
Maine	366.54	N
Maryland	480.45	Y
Massachusetts	565.63	Y
Michigan	1240.77	Y
Minnesota	912.73	Y
Mississippi	730.64	Y
Missouri	1384.83	Y
Montana	1191.23	N
Nebraska	81.66	N
Nevada	596.15	Y
New Hampshire	224.54	Y
New Jersey	431.36	Y
New Mexico	999.9	N
New York	1714.56	Y

North Carolina	1241.98	Y
North Dakota	571.13	N
Ohio	1572.35	Y
Oklahoma	930.16	Y
Oregon	727.41	Y
Pennsylvania	1858.34	Y
Rhode Island	68.53	Y
South Carolina	850.8	Y
South Dakota	678.31	N
Tennessee	1940.34	Y
Texas	3432.95	Y
Utah	938	Y
Vermont	320.22	N
Virginia	1117.23	Y
Washington	763.67	Y
West Virginia	549.05	Y
Wisconsin	741.8	Y
Wyoming	913.6	N
Washington DC	12.27	Y
Puerto Rico	249.77	Y
Total	48298.93	

APPENDIX B

SURVEY QUESTIONS

In this section complete list of the survey questions and answer choices have been provided.

1. **How much does your district/agency use the following tools as the primary means of collecting travel time information? Please enter one response per row.**
    - Loop detectors Radar Bluetooth
    - Cameras
    - Third party (such as INRIX)
    - Other (comment below)
2. **To meet the new Federal Regulation, transportation agencies must provide travel times for limited access roadways within a metropolitan statistical area greater than 1,000,000 in population. How much does your agency need to expand your travel time coverage to meet the Regulation?**
    - Not applicable, my district/agency does not serve a metropolitan area
    - None, my district/agency already provides travel times for the required facilities
    - We need to expand (comment on approximately how many more miles require travel time collection below)
3. **How much does your district/agency process field data, such as speeds, into travel times using each of the following tools? Please enter one response per row.**
    - Software developed within your agency

- Software purchased from a vendor
- Other (comment below)

4. **What guides or will guide your district's/agency's collection, processing, and dissemination of travel time data? Select all that apply.**
   - An existing policy/guideline
   - A forthcoming policy/guideline
   - Standard practices within your offices
   - Nothing that you are aware of
   - Other (please explain)
5. **What is your District's/Agency's standard practice for considering travel time information as "accurate"?**
   - Within 1%
   - Within 5%
   - Within 10%
   - Within 15%
   - Within 20%
   - Within 1 minute
   - Within 2 minutes
   - Undefined
   - Other
6. **How does your district/agency identify if a travel time is not accurate? Select all that apply.**

- Expertise of personnel (employees intimately aware of average range of times at different traffic conditions)
- Higher than normal calls/complaints from the public
- Other (please explain)

7. **When you become aware that a travel time may not be accurate, how is travel time accuracy checked? Select all that apply.**
    - Field runs with a test vehicle
    - Field runs with a probe vehicle (such as a freeway service patrol)
    - Online sources such as Google Maps
    - Cameras
8. **If you collect travel times with probe vehicles, do you follow statistical sampling techniques?**
    - Yes
    - No
9. **Please indicate which of the following are ways that the public can access your district's/agency's travel time information. Please enter one response per row.**
    - Website
    - Email
    - Text message system
    - Dynamic message signs (DMS)
    - Portable DMS Highway advisory radio
    - 511 system
    - Apps

- Social media (twitter, etc.)
- Other (comment below)

10. What methods are used to require contractors to provide real-time lane closure information?

- Existing specifications
- Existing special provisions
- Existing general notes on plans
- Proposed specifications
- Proposed special provisions
- Proposed general notes on plans
- None
- Standard practices

11. How does your district/agency learn about real-time construction lane closures?

- Contractors are required to inform our district/agency
- We only know about planned lane closures
- Agency Staff (DOTs)

12. How does your district/agency provide construction lane closure information to the public? Please enter one response per row.

- Website
- Email
- Text message system
- Dynamic message signs (DMS)
- Portable DMS

- Highway advisory radio
- 511 system
- Apps
- Social media (twitter, etc.)
- Other (comment below)

13. What requires law enforcement and emergency management services to notify your district/agency about traffic incidents (on limited access roadways) in real-time? Select all that apply.

- Existing policy/guidelines
- Proposed policy/guidelines
- Nothing, but current standard practices are satisfactory
- Nothing and current practices do not provide real-time information to travelers

14. During normal business hours and after you are informed of a traffic incident, how quickly do you normally send this information to the public (in any form)? (minutes)

15. Outside of normal business hours, how quickly do you normally send incident information to the public (in any form) after you are informed?

- We operate 24 hours a day
- We send this information within approximately this number of minutes

16. How does your district/agency provide traffic incident information to the public? Please enter one response per row.

- Website
- Email

- Text message system
- Dynamic message signs (DMS)
- Portable DMS
- Highway advisory radio
- 511 system
- Apps
- Social media (twitter, etc.)
- Other (comment below)

17. How much does your district/agency use each of the following to collect weather information? Please enter one response per row.

- Roadside weather information systems (RWIS)
- National Weather Service
- Weather contractor
- Probe Vehicles
- Other

18. During severe weather events, how frequently does your district/agency receive information from field vehicles, such as snow plows, and other sources (select all that apply)?

- You do not receive any information from your field vehicles
- Your drivers provide updates every two hours
- Your drivers provide updates every hour
- Your drivers provide updates every half hour
- Your drivers provide updates every quarter hour

- Electronic system provides updates in real-time
- Calls from travelers
- Other (please explain)

19. How does your district/agency provide weather information to the public? Please enter one response per row.

- Website
- Email
- Text message system
- Dynamic message signs (DMS)
- Portable DMS
- Highway advisory radio
- 511 system
- Apps
- Social media (twitter, etc.)
- Other (comment below)

20. What agency do you represent?

21. If your agency has a website for disseminating traveler information, please provide the address(es) here:

22. How much do you agree with the following statement. I am familiar with the new Federal Real-Time Systems Management Information Program requirements?

- Strongly agree
- Agree

- Neither agree nor disagree
- Disagree
- Strongly disagree
- Other (please explain)

23. In your opinion, what is the most challenging aspect of meeting the spirit of the new Federal Real-time Systems Management Information Program requirements?

24. In your opinion, how much do you agree that each of the following has prepared your transportation agency for the inter-agency communications needs of the new Real-time Systems Management Information Program requirements?

- NIMS training
- NIMS Incident Command System training
- Other inter-agency training
- EM training exercises
- Following a state Intelligent Transportation Systems (ITS) architecture
- Following a regional ITS architecture
- Not familiar enough

25. Please characterize the population density of the travelers you serve in your coverage area. Select all that apply.

- All
- Only Rural
- Urban/Suburban
- Only Urban

- Suburban/Rural
- Urban/Rural
- Only Suburban

26. Approximately how many center lane miles of interstate does your district/ agency serve?

APPENDIX C

RAW DATA OF SOME SURVEY RESPONSES

This chapter has some of the raw data from the survey which has not been cover in the previous chapters.

➢ **What methods are used to require contractors to provide real-time lane closure information? Please provide a reference or specific name to any documents you listed above.**

- NDOT Silver Book
- Construction team must submit RNF for planned construction, then MassDOT personell input this information in the Event Reporting System, which disseminates real time advisories to pertinent traveler information resources.
- N/A
- 511 policy, driver's first policy
- Temporary traffic control plan
- Specials are contract specific and I don't have a a ready link
- Not aware of the exact spec - we've moved it around to put it in places that contractors look most often.
- epg.modot.org

- KanRoad (includes KTA) – Statewide KC Scout – Regional WICHway – Regional (planned) 511 Procedures KanDrive Maintenance Plan Maintenance Manual Standard Operating Manual (SOM), as appropriate Work Zone ITS (Planned)
- We require a Lane Closure Request Form to be filled out prior to any work done on state roadways. Even shoulder closures
- Lane Closure System

➢ **Prior to preparing to meet the Real-time Systems Management Information Program requirements, how quickly was your district/agency normally notified about construction lane closures? (hours)**

- Inconsistent throughout the state
- varies
- unknown
- 0 hours - CHART should be notified prior to any lane closures
- As needed
- All planned closures generally require a press release, so in time to get that out (a few days)
- Varies from minutes to days prior to the activity depending on the location and activity being performed.
- The construction engineer is notified right away but then has to enter the information into the system which can take time or they may not do it right away so this varies a

great deal. We do not post anything on the website or 511 that will last less than 2 hours.

- 1 hour
- n/a
- Depentant on contract requirements which are typically tied to the impact of the proposed closure
- before it actually took place
- Our requirments and procedures were in effect well before teh RTSMIP requirements
- NA
- usually either promptly or not at all.
- 48 hours prior to closure
- Varies by geographic area and organization - no formal system
- 72 hours in advance of closures is our internal requirement
- No change.
- We have required the Lane Closure request form since 2006. We have always made great efforts to get this information.
- Within minutes
- 8-72 hours
- Eight Hours

➢ **If your agency has a website for disseminating traveler information, please provide the address(es) here:**

- www.nvroads.com

- https://mass511.com/ http://www.massdot.state.ma.us/highway/TrafficTravelResources/TrafficInformationMaps.aspx#Road Work http://www.massdot.state.ma.us/DevelopersData.aspx
- idrivearkansas.com
- http://tims.ncdot.gov/tims/
- http://511.idaho.gov/
- MD SHA - http://www.marylandroads.com CHART - http://www.chart.state.md.us/ MD 511 - http://md511.org/default.aspx
- Wyoroad.info
- www.511ny.org
- http://web-2.trafficwise.org/pws/ http://indot.carsprogram.org/#roadReports/layers=allReports,roadReports,weatherWarnings,trafficSelectAll,googleTraffic,trafficWise http://netservices.indot.in.gov/RWIS/ http://www.in.gov/indot/2420.htm
- http://www.dot.nd.gov/travel-info-v2/
- www.mdottraffic.com
- n/a
- CHART - http://www.chart.state.md.us/ MD 511 - http://md511.org/default.aspx
- Traffic, incidents, construction: http://www.wsdot.com/traffic/trafficalerts/

weather: http://www.wsdot.com/traffic/weather/default.aspx

Review the left column of each of these pages to see all the options we offer.

For email and text services:

https://public.govdelivery.com/accounts/WADOT/subscriber/new?

For App info: http://www.wsdot.com/Inform/mobile.htm

- www.511vt.com
- www.michigan.gov/drive
- http://roadweather.alaska.gov http://511.alaska.gov
- udottraffic.utah.gov (traveler information) udot.bt-systems.com (traffic data archiving)
- www.modot.org
- www.kcscout.net
- http://www.511sc.org/
- www.511ga.org
- http://mdt.mt.gov/travinfo/
- www.511ga.org
- www.511nj.org
- NA
- safetravelusa.com

- 511wi.gov
- www.511ia.org