State of the Practice for Traveler Information During Nonrecurring Events

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Pedestrian and Bicycle Safety

FOREWORD

The Federal Highway Administration has recognized the need to take a comprehensive look at the information requirements and decisionmaking processes of travelers across a range of nonrecurring events. Properly constructed and presented traveler information about nonrecurring events provided at key decision points can be a powerful tool for operators and managers to better inform travelers of those events. The purpose of this project was to identify, review, and synthesize literature and best practices on efforts to understand travelers' information needs and related decisionmaking processes during nonrecurring events.

The intended target audience for this report includes transportation professionals involved in the management, planning, engineering, research design, and operations of traffic and traveler information systems. The information presented in this report has the potential to help transportation professionals and researchers provide optimal traveler information on roadway networks to allow users to make better route choices, thereby decreasing travel time and congestion.

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The Federal Highway Administration has recognized the need to take a comprehensive look at the information requirements and decisionmaking processes of travelers across a range of nonrecurring events. The goal of this study was to review and synthesize information about travelers’ information needs and current practices for information dissemination related to nonrecurring events. Researchers identified, reviewed, and synthesized academic literature, practitioner reports, and best practices for information provision related to nonrecurring events. This report discusses user needs, best practices, data collection and information dissemination technologies, and knowledge gaps. Case studies and information dissemination strategies are also provided.</td></tr>
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SI* (MODERN METRIC) CONVERSION FACTORS

APPROXIMATE CONVERSIONS TO SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
in	inches	25.4	millimeters	mm
ft	feet	0.305	meters	m
yd	yards	0.914	meters	m
mi	miles	1.61	kilometers	km
		AREA		
in^2	square inches	645.2	square millimeters	mm^2
ft^2	square feet	0.093	square meters	m^2
yd^2	square yard	0.836	square meters	m^2
ac	acres	0.405	hectares	ha
mi^2	square miles	2.59	square kilometers	km^2
		VOLUME		
fl oz	fluid ounces	29.57	milliliters	mL
gal	gallons	3.785	liters	L
ft^3	cubic feet	0.028	cubic meters	m^3
yd^3	cubic yards	0.765	cubic meters	m^3
		NOTE: volumes greater than 1000 L shall be shown in m^3		
		MASS		
oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2000 lb)	0.907	megagrams (or "metric ton")	Mg (or "t")
		TEMPERATURE (exact degrees)		
^oF	Fahrenheit	5 (F-32)/9 or (F-32)/1.8	Celsius	^oC
		ILLUMINATION		
fc	foot-candles	10.76	lux	lx
fl	foot-Lamberts	3.426	candela/m^2	cd/m^2
		FORCE and PRESSURE or STRESS		
lbf	poundforce	4.45	newtons	N
lbf/in^2	poundforce per square inch	6.89	kilopascals	kPa

APPROXIMATE CONVERSIONS FROM SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
mm	millimeters	0.039	inches	in
m	meters	3.28	feet	ft
m	meters	1.09	yards	yd
km	kilometers	0.621	miles	mi
		AREA		
mm^2	square millimeters	0.0016	square inches	in^2
m^2	square meters	10.764	square feet	ft^2
m^2	square meters	1.195	square yards	yd^2
ha	hectares	2.47	acres	ac
km^2	square kilometers	0.386	square miles	mi^2
		VOLUME		
mL	milliliters	0.034	fluid ounces	fl oz
L	liters	0.264	gallons	gal
m^3	cubic meters	35.314	cubic feet	ft^3
m^3	cubic meters	1.307	cubic yards	yd^3
		MASS		
g	grams	0.035	ounces	oz
kg	kilograms	2.202	pounds	lb
Mg (or "t")	megagrams (or "metric ton")	1.103	short tons (2000 lb)	T
		TEMPERATURE (exact degrees)		
^oC	Celsius	1.8C+32	Fahrenheit	^oF
		ILLUMINATION		
lx	lux	0.0929	foot-candles	fc
cd/m^2	candela/m^2	0.2919	foot-Lamberts	fl
		FORCE and PRESSURE or STRESS		
N	newtons	0.225	poundforce	lbf
kPa	kilopascals	0.145	poundforce per square inch	lbf/in^2

*SI is the symbol for the International System of Units. Appropriate rounding should be made to comply with Section 4 of ASTM E380. (Revised March 2003)

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LIST OF ABBREVIATIONS

ATIS	advanced traveler information system
CB	citizen band
CCTV	closed-circuit television
CMS	changeable message sign
DMS	dynamic message sign
ESS	environmental sensing system
FHWA	Federal Highway Administration
GPS	Global Positioning System
HAR	highway advisory radio
ITE	Institute for Transportation Engineers
ITS	intelligent transportation system
MnDOT	Minnesota Department of Transportation
PASSAGE	Program for Arterial Signal Synchronization and trAvel GuidancE
PLA	problem, location, and action
RITIS	Regional Integrated Transportation Information System
RS-D	roadside detection
RWIS	road weather information system
TMC	traffic management center
TRB	Transportation Research Board
VDOT	Virginia Department of Transportation
VMS	variable message sign
WisDOT	Wisconsin Department of Transportation
WSDOT	Washington State Department of Transportation

EXECUTIVE SUMMARY

The Federal Highway Administration has recognized the need to take a comprehensive look at the information requirements and decisionmaking processes of travelers across a range of nonrecurring events, which include unplanned or planned events that impact traffic conditions. Unplanned events may include traffic incidents, severe weather, and emergencies, while planned events may include road work, sporting events, concerts, marathons, county fairs, parades, political rallies, planned protests, and holiday celebrations. Whether planned or unplanned, because these events are nonrecurring, travelers may not expect them, and they may cause disruptions to travel as well as impair broader network flow. The provision of information about these events can help drivers make informed decisions that minimize the impact of these events. In order to provide effective information, it is important to understand travelers' information needs and preferences.

Information dissemination modes include both pre-trip and en-route messages. Pre-trip information may include TV, radio, text or email alerts, websites (including 511), and mobile mapping applications (referred to as "apps" throughout this report) with traffic information. En-route information may include many of the previously listed media as well as changeable message signs (CMSs), highway advisory radio, and in-vehicle devices linked to the connected vehicle ecosystem. Thanks to rapid expansion of wireless communication technologies, travelers have access to more information in more places than ever; however, it is important to understand exactly what information travelers need, when they need it, and how they want to receive it.

The purpose of this study was to identify and review literature and synthesize the best practices on efforts to understand traveler information needs and related decisionmaking processes within the context of nonrecurring events. This report provides a comprehensive, up-to-date review that is easily accessible for use with present-day challenges while also being forward-looking for upcoming trends and advances as the landscape of nonrecurring events information evolves.

Traveler behavior involves individual decisionmaking, such as what trips to make, where to visit, when to depart, what mode of travel to utilize, and what route to follow.(1) *Decisionmaking* is defined as the thought process for selecting a logical choice from the available options by weighing the positives and negatives of each option and considering all the alternatives.(2) It is not always an error-free process and can be affected by various factors, including, but not limited to, fatigue, lack of information, perceived or real-time pressure, and stress.(3) In addition, when in an unknown situation that may elicit stress, decisionmakers (e.g., drivers or travelers faced with information about a nonrecurring event) may do the following:

- Seek out certainty (and be less tolerant of ambiguity).
- Attempt to make fast decisions and seek out closure.
- Narrow perception due to sensory overload (e.g., tunnel vision).
- Demonstrate suboptimal judgment due to perception distortion.
- Have a decreased capacity to handle complex tasks.
- Choose risky alternatives.

In addition, not all decisionmakers operate or approach, perceive, and navigate problems the same way. Individual differences, such as age, familiarity with the area, culture/language, and personality can have an impact on the effectiveness of pre-trip and en-route messages.

According to Torma-Krajewski and Powers, an effective decisionmaker is confident and competent, is knowledgeable of the situation, seeks advice, takes advantage of opportunities, remains flexible and open to new options, is calculated and selective, takes a comprehensive approach, has the initiative to make a decision, and has a good understanding of his or her own abilities.[4] More specifically, driver-related decisions should be timely, minimize damage, and accomplish a specific objective or mission while keeping everyone safe. To reduce the difficulties experienced by drivers in decisionmaking environments, all forms of uncertainty must be minimized, and all information necessary to make a good decision should be provided at the time that the decision needs to be made.

Certain precautions must be taken when developing strategies for assisting the decisionmaking process, especially in situations of nonrecurring events where there may be limited or rapidly changing information (e.g., evacuations and emergency situations). For example, an overload of information can contribute to poor decisionmaking, cause drivers to forget already processed information, induce mental fatigue, or delay the actual decision.[4] This report reviews literature regarding information needs for nonrecurring events, as noted in surveys and focus groups of the traveling public (both nationally and internationally).

Both public and private sector entities have roles in the process of disseminating information to the public. For example, many State transportation departments or other Government entities send alerts via text message or email, post messages on CMSs, and provide traveler information via automated telephone services and websites. Common information available on traveler information websites includes maps showing color-coded traffic conditions, incident locations, CMS messages, travel times, traffic cameras, and weather conditions. Many agencies have also expanded their outreach to social media platforms such as Twitter™ and Facebook®. In addition, comprehensive collection of real-time traffic information from sources such as private vendors and State transportation departments can help agencies detect and respond to unplanned events, such as collisions.

In the private sector, mapping apps can provide travelers with pre-trip and en-route directions and traffic information. While much of the focus on traveler information is on drivers, the utility of traveler information can be enhanced by providing multimodal information, such as bus and train schedules, online and at transit stations. Partnerships between various public and private entities (e.g., mapping companies, news media, and the Government) can also help to expand the quality and availability of information.

In the past decade, the quality and availability of traveler information have expanded dramatically.[5] In the future, this trend is likely to continue. One major new development in traveler information is connected vehicle technology, which allows vehicles to wirelessly communicate with one another and with highway infrastructure. This new technology provides vehicles with traveler information to a much greater degree than in the past. While this technology has great potential to improve the information available to drivers, it also brings challenges, such as developing interfaces that are safe to use while driving.

The section entitled Message Types and Examples in chapter 3 as well as table 3 in appendix A provide a taxonomy of message types that can be used for traveler information about nonrecurring events. The appendix indicates event type, messages that can delivered at various times (before an event, at the time of an event, after an event has begun, etc.), the delivery method, and example messages. Events addressed include incidents, work zone, and weather-related events. Appendix A can be used as a tool to plan messaging strategies for a wide range of potential nonrecurring events.

There are a variety of methods to assess the public's use, perception, and effect of traveler information systems. Traditional methods have included call statistics, website hits, and satisfaction surveys. Based on prior experiences and findings, a toolbox method could be used to evaluate traveler information systems (specifically nonrecurring events messaging).(6) This approach combines a variety of focused, targeted, and low-cost methods (e.g., focus groups, traveler logs or diaries, and targeted surveys) that evaluate different aspects of a traveler information program in a particular area. It is also desirable to use a combination of methods due to the large variety of dissemination methods, traveler characteristics, and information types. Findings from these methods can then be combined to generate a profile of overall system effectiveness, especially with respect to its effect on trip behavior as a result of nonrecurring events.

The intended audience for this report includes transportation agencies interested in implementing or managing a traveler information system that includes information for nonrecurring events as well as researchers investigating traveler needs and behaviors related to nonrecurring event information.

CHAPTER 1. INTRODUCTION

BACKGROUND AND OBJECTIVES

Incident-related and other nonrecurring congestion are major contributors to total congestion delays on highways. For example, it has been estimated that roughly half of all delays on freeways in the United States are due to nonrecurring causes.(7) Types of nonrecurring events may include traffic incidents, severe weather, work zones, emergencies, and sporting events. Devices and media that can be used to convey information about nonrecurring events to travelers may include mobile apps, changeable message signs (CMSs), telephony, websites, radio, and in-vehicle devices that may become part of the connected vehicle ecosystem. It is important to review outcomes from a traveler's perspective regarding access to, perception of, and need for traveler information surrounding nonrecurring events. It is also essential to take into consideration that in order for information for nonrecurring events to be optimally presented, it must match user needs in both content and media. Examination of the ever-expanding role of the private sector in existing and future real-time advanced traveler information systems (ATISs) were also considered throughout.

The purpose of this task order was to identify and comprehensively review literature and synthesize best practices on efforts to understand travelers' information needs and related decisionmaking processes within the context of nonrecurring events. The ultimate goal was to find what information will help the traveling public make the most effective and safest travel decisions during nonrecurring events.

This report presents a comprehensive review that is up to date and easily accessible for use with present-day challenges while also being forward-looking for upcoming trends and advances as the landscape of nonrecurring events information evolves. This review emphasizes clarity, relevance, and ease of use for a wide range of potential users. It can be used as a tool to understand how to anticipate and adapt to user needs and decisionmaking processes in a range of nonrecurring event situations. Information about nonrecurring events had traditionally been investigated from the perspective of agency dissemination practices and considered a limited range of situations. The best dissemination practices, however, must also account for the audience and needs of the public.

METHODOLOGY

The research effort began with keyword searches of relevant databases with an emphasis on recent information.(8) To be fully comprehensive, the review also included information gathered from international sources.(9,10) Each search included a combination of keywords as well as supplemental keywords used to refine search results. The following five main search categories were created to encompass the key project dimensions, as outlined in the statement of work: (1) core concept, (2) data and technology, (3) location, (4) specific technologies, and (5) supplementary terms. Using these categories, a list of search terms was then compiled and organized appropriately. As an example, the search terms "traveler information" and "incident" were both placed in the core concept category. The following list shows an initial sample set of search terms organized by the five key search categories:

- **Core concept**: Traveler information, nonrecurring events, decisionmaking, weather, work zone, incident, special event (planned), event, user, and travel time.

- **Data and technology**: ATIS, intelligent transportation system (ITS), technology, real time, dissemination, and instrumentation.

- **Location**: Pre-trip, en route, and destination.

- **Specific technologies**: Connected vehicle, CMS, highway advisory radio (HAR), 511, mobile apps, cell phones, and Global Positioning System (GPS).

- **Supplementary terms**: Guidelines, best practices, operations, traffic, congestion, requirements, implementation, and reliability.

Additional search terms were added and adjusted for follow-up searches.

Boolean logic was applied to further define the search. Search terms from the five categories were combined with Boolean operators (AND, OR, etc.) to exclude irrelevant literature and limit results to within the project scope. For example, in an initial search, terms from the core concept, location, data and technology, and specific technologies categories were combined in a way that would return literature containing any of the keywords in any of the categories. Due to search character limits, this Boolean combination can be divided into a series of searches as follows:

- (“nonrecurring event” OR “traveler information” OR “user”) AND (en-route OR pre-trip) AND (“smartphone apps” OR “changeable message sign” OR “radio” OR “511”)*.

- (“nonrecurring event” OR “traveler information” OR “user”) AND (“intelligent transportation system” OR “ATIS”) AND (“connected vehicle” OR “cell phone”)*.

Note that the asterisk represents a “wildcard” character. In anticipation of these search terms returning thousands of documents, in each case, the first 100 search results were carefully screened. Relevant literature was identified, as defined by the project dimensions and the statement of work. Additionally the following avenues were reviewed:

- **Societies and committees**: Several societies and committees were reviewed to aid in information gathering and outreach, such as the following:

    - Transportation Research Board (TRB) (e.g., Regional Transportation Systems Management and Operations Committee and Freeway Operations Committee).

    - ITS America (e.g., Information Communication Forum).

    - ITS World Congress.

    - Institute for Transportation Engineers (ITE) (e.g., Transportation Systems Management and Operations Council and associated committees).

- American Association of State Highway and Transportation Officials, including the Subcommittee on Traffic Engineering.
    - Institute of Electrical and Electronics Engineers.
    - National Committee on Uniform Traffic Control Devices.
    - Consumer electronics meetings and relevant committees.
    - International organizations and committees (e.g., ERTICO ITS Europe is a partnership of around 100 companies and institutions involved in the production of ITSs).

- **Conference proceedings**: Conference proceedings were searched because developmental work and practices are often presented there. Conferences conducted by the organizations mentioned in the previous list were a starting point for a search. (Note that helpful conference proceedings are documented throughout the report.)

- **Social networking**: It was important to utilize social communities through sites such as LinkedIn®, Facebook®, and online community forums (e.g., ITE Community) to share information among practitioners who are tackling many of the challenging topics regarding traveler information for nonrecurring events.

- **Industry contacts**: Informal meetings often aid in providing a view into trends. Industry contacts were established and contacted throughout the research process. The team reached out to traffic management center (TMC) pooled fund study members along with engineers, ITS managers, TMC systems operators at State transportation departments, and other contacts via email and telephone to conduct brief interviews. This allowed the team to leverage contacts from other projects simultaneously.

- **News:** News websites, magazines, and trade journals were searched. (Note that helpful websites, magazines, and trade journals are documented throughout the report.)

Once key sources were identified, they were analyzed in terms of the following:

- Range of content and level of detail.

- Treatment of general principles, techniques, specific parameters, and features that could be applied to the task at hand.

- Relevance—both technological and practical.

- Audience/practitioner, including driver needs and desires of content, mode, and timing.

- Potential for impact on traveler information operations, management, and dissemination.

ORGANIZATION OF REPORT

The remainder of the report is organized into the following chapters:

- Chapter 2 discusses traveler information needs and decisionmaking processes around nonrecurring events.
- Chapter 3 provides a brief overview of agencies' dissemination methods and practices to provide a general impression of the range of available methods, emerging technologies, and trends.
- Chapter 4 highlights some of the common challenges and issues practitioners face when implementing a traveler information system for nonrecurring events.
- Chapter 5 presents two brief case studies of successful traveler information for nonrecurring event implementations. The case studies were chosen from the set of implementations briefly discussed in chapter 2.
- Chapter 6 presents lessons learned and conclusions.
- Appendix A provides example messages for a range of events as well as information regarding message timing in respect to the event and delivery method.
- Appendix B offers a sampling of mobile apps from State transportation departments and other regional sources.

CHAPTER 2. USER INFORMATION NEEDS AND DECISIONMAKING

Schofer, Khattak, and Koppelman define *traveler behavior* as the process of individual decisionmaking about what trips to make, where to visit, when to depart, what mode of travel to utilize, and what route to follow.[(1)] In the rapidly changing environment of today's society, individual needs and trip purpose are often fluctuating. Pre-trip information, such as the location of traffic incidents and traffic congestion, is often available from a variety of sources, such as local news and radio reports. This chapter highlights traveler decisionmaking, user information needs, and traveler behavior.

Decisionmaking is defined as the thought process for selecting a logical choice from the available options by weighing the positives and negatives of each option and considering all the alternatives.[(2)] Decisionmaking is not always an error-free process and can be affected by various factors including, but not limited to, fatigue, lack of information, perceived or real-time pressure, and stress.[(3)] In addition, when in an unknown situation that may elicit stress, decisionmakers (e.g., drivers or travelers faced with information about a nonrecurring event) may experience the following:

- Seek out certainty (and are less tolerant of ambiguity).
- Attempt to make fast decisions and seek out closure.
- Narrow perception due to sensory overload (e.g., tunnel vision).
- Demonstrate suboptimal judgment due to perception distortion.
- Experience decreased capacity to handle complex tasks.
- Choose risky alternatives.

In addition, not all decisionmakers operate or approach, perceive, or navigate problems the same way. As a result, the following individual differences can have an impact on how travelers understand traffic-related messages:

- Age-related differences in processing, perceiving, and understanding messages as well as the decisions and strategies chosen.

- Personality differences in style, types, and preferences.

- Cultural/language (including regional differences within the United States).

- Familiarity with area (e.g., local commuters versus tourists).

Information influencing driver decisionmaking has three layers. The first layer is the initial observation, which includes providing primary information. The second layer is secondary information (i.e., passive messages). The third layer is the tertiary information, which represents the actively sought specifics. When providing information to drivers, the goal is to help them make a decision to avoid disruption at the highest level with the least amount of interaction with traveler information sources.

According to Torma-Krajewski and Powers, an effective decisionmaker is confident and competent, is knowledgeable of the situation, seeks advice, takes advantage of opportunities, remains flexible and open to new options, is calculated and selective, takes a comprehensive approach to decisionmaking, has initiative to make a decision, and has a good understanding of his or her own abilities.[4] Specifically, driving-related decisions should be timely to minimize delays resulting from driving into an incident or other delay-inducing events, such as work zones, and should accomplish a specific objective or mission. To reduce the difficulties experienced by drivers when confronted with decisions, all forms of uncertainty must be minimized, and all information necessary to make a good decision should be provided at the time that the decision needs to be made.

Certain precautions must be taken when developing strategies for assisting the decisionmaking process, especially in situations of nonrecurring events where there may be limited or rapidly changing information (e.g., evacuations and emergency situations). For example, providing too much information can cause drivers to forget already processed information, which may induce mental fatigue or delay the actual decision.[4]

INFORMATION NEEDS FOR NONRECURRING EVENTS

When reviewing research findings about travelers' information needs and wants for nonrecurring events, it is important to consider how rapidly the traveler information environment is evolving. For example, dynamic message signs (DMSs) and other ITS features have become increasingly common, and Internet sources or social media in particular (e.g., Twitter™) have become much more prevalent, reliable, and, popular. Smartphones in particular have allowed travelers to access an incredible amount of information in real time wherever they are, including on the road. The rapid evolution of traveler information options and availability means that information about traveler preferences for routing can be outdated even if the data are only a few years old. Therefore, the literature discussed in this section should be considered with that caveat in mind.

Higgins et al. conducted a study on behalf of the Wisconsin Department of Transportation (WisDOT) to better understand drivers' decisionmaking processes when faced with unexpected lane restrictions or closures.[11] The researchers conducted focus groups and traveler surveys with commuters in two Wisconsin cities ($n = 20$, where n is the total number of observations). Focus group results showed that traffic congestion and travel speed were primary factors in determining route choice for commutes. During hazardous weather such as snow, the perceived safety and accessibility of the route was a factor. For example, some drivers preferred driving on freeways because of specific features such as divided traffic and wide shoulders. About half of the participants indicated that they check traffic conditions at least occasionally before beginning a trip using a variety of information sources, including WisDOT's website, TV, radio, and mobile apps.[12] Participants were mixed in their willingness to divert to alternate routes. Factors in choosing an alternate route included the availability of viable alternates, expectation of time savings, and easy access to relevant traveler information. The focus groups revealed that participants were sometimes suspicious of alternative route suggestions because of concerns that the alternate route would be overburdened by diverting traffic.[11] They also expressed uncertainty about whether the alternative was consistent with the planned destination as well as that the alternative might be less direct than the current route.

When asked about their information needs and preferences, participants expressed an interest in obtaining information related to traffic, roadway, and weather conditions.(11) If participants encountered a delay-causing event, most wanted to know the cause of the delay, the length of the expected delay, travel time on the original route, and the time that the delay was expected to be resolved. Some participants also wanted to know pre-trip route planning information, recommended exit numbers to divert around a delay, and messages about special events that could affect traffic. They also expressed the desire for obtaining advance notifications prior to a diversion point.

When asked about specific information sources, participants generally liked DMS messages.(11) Few had used HAR, 511, the WisDOT mobile website, or traffic mobile apps.(12) Participants had mixed opinions of receiving text messages due to the risks of reading text messages while driving.

Higgins et al. also conducted focus groups with commercial vehicle drivers.(11) These drivers frequently received traffic information from other drivers via citizen band (CB) radio and could choose an alternate route based on previous experience or guidance from dispatch. They also used DMS while en route. Drivers were aware of the availability of traffic incident alert information, but because the alerts were given for the entire State with no customization option, most drivers chose not to receive these alerts.

When asked about their information needs and preferences, commercial drivers indicated that they wanted detailed information about planned construction over the next 10 d, traffic and delays, length of delay, and bridge height/weight for available routes.(11) It would also be beneficial to create a commercial driver page on the WisDOT website as well as additional mobile traffic information resource apps and real-time text-to-voice message updates.(12)

Higgins et al. also conducted traveler information surveys at DMV locations and online (n = 287).(11) Results show that the most commonly used sources of traveler information for drivers were travel websites other than WisDOT/511 (such as other private sector online mapping tools), road signs/DMSs, radio, mobile apps, mobile websites, and television. It is notable that participants were more than three times as likely to use a non-State transportation department website than a State transportation department website.(11)

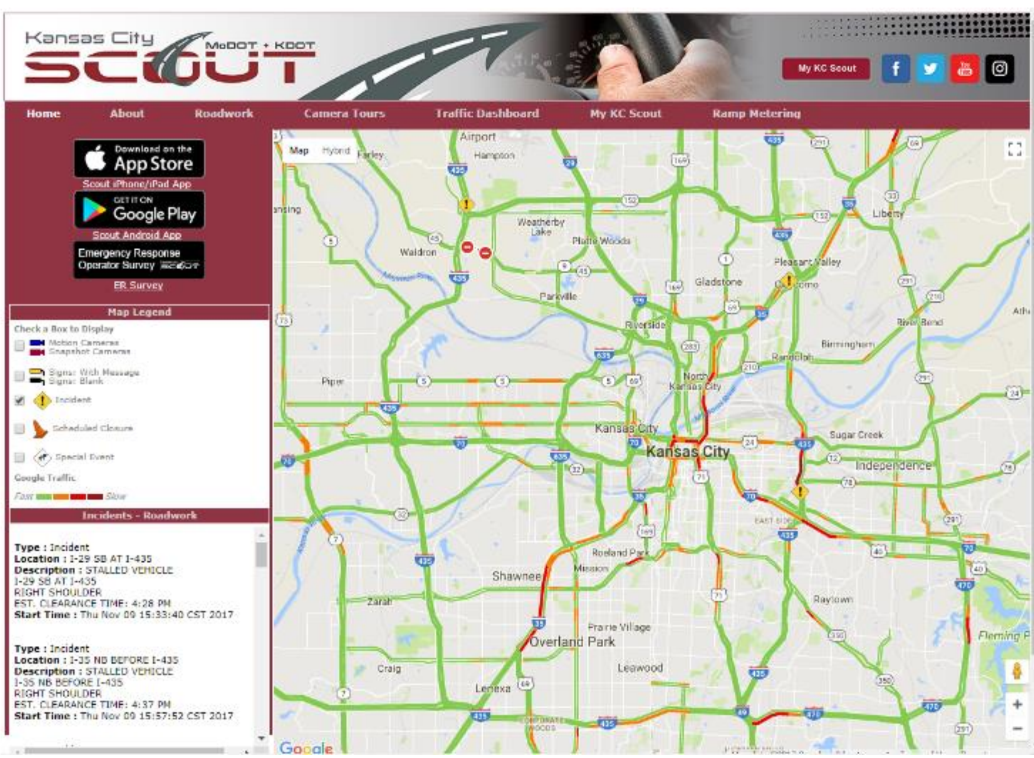
When participants were asked about the types of information they wanted to receive about a delay, the answers, from most to least important, were length of delay, recommendations for alternate routes, general traffic-related messages indicating that drivers should take an alternate route, and expected travel time on usual route.(11) When asked about specific information related to alternate routes, participants most wanted to know how long the congestion delay on the usual route would last, travel time on the alternative route, and the name of the alternative route. If the information was for an unfamiliar trip, turn-by-turn directions for the alternate route and a map of the alternate route were especially desirable regardless of the source.

A survey conducted by Sun et al. investigated the route choices of truck drivers.(13) Data collection took place during February and June 2012 at three rest area and truck stop locations along major highways in Texas and Indiana as well as Ontario, Canada. Part of the survey questioned truck drivers about the sources of information that affected their routing choices.

Commonly cited factors included prior experience/knowledge, maps, and navigation systems. While en route, the most common source of information was other truck drivers via CB radio. When considering whether to choose an alternate route, truck drivers were likely to consider the availability of fueling stations, predictability of travel time, and availability of truck parking.(13)

Schroeder and Demetsky investigated the effects of various DMS content strategies on the likelihood that drivers would choose one of two viable alternate routes (i.e., I-95 or I-295) in the Richmond, VA, area.(14) Results showed that changes in DMS wording could influence diversion rates or the number of drivers who actually decided to take an alternative route after seeing the DMS message. The authors recommended that traffic managers provide estimates of travel times for the original route and alternate routes to encourage diversion. DMS text should be consistent in format, use one-phase messages, avoid all capital letters, and be staircase or left-justified.

The Kansas City Scout Advanced Traffic Management System is a comprehensive traveler information and traffic congestion management system that is a joint effort between the Missouri and Kansas TMCs. Kansas City Scout has two main traveler information dissemination methods: its website (see figure 1) and CMSs.(15) The website shows a live traffic map of Kansas City, MO/KS. The map also includes clickable live traffic cameras and CMS messages, as well as locations of incidents, scheduled closures, and special events. Once on the road, drivers can use the network of freeway CMS. These CMSs are primarily used to provide travel time information but can also be used to provide incident information.



Screen Capture ©Kansas City Scout, Kansas Department of Transportation, and Missouri Department of Transportation (Map in screen capture ©Google® Maps™).

Figure 1. Screenshot. Kansas City Scout website.(15,16)

To gauge driver feedback, Kansas City Scout conducted a mobility survey in spring 2015. The survey gathered feedback about preferred ways for travelers to receive real-time traffic information pre-trip and en route. Survey results indicated that before beginning trips, the preferred information source for drivers was the Kansas City Scout website map and mobile app.[15,17] While en route, drivers indicated that DMSs were the preferred means for obtaining real-time traffic information. The survey also asked drivers about their preferences for the types of information that they would like to see on DMSs. Drivers ranked DMS messages in the following order of importance: (1) incident and lane closures, (2) roadwork, and (3) weather updates.

INTERNATIONAL PERSPECTIVE REGARDING TRAVELER PREFERENCES

Chang et al. investigated automobile and commercial travelers' requirements of multimodal travel information systems in New Zealand.[9] The research was carried out between October 2014 and May 2015 in several stages, which included surveying the public through indepth user interviews and online surveys at sites in Dunedin and Auckland. Through the survey, drivers across both cities identified delays, detours, and parking information as their top three pre-trip information needs. Across both cities, important information sought en route included road closure, delay, and detour information. In Auckland, route planning and trip duration was ranked higher as a pre-trip need than in Dunedin. The authors speculated that this may be due to Auckland's size and longer commuting times and distances along with having a more complex transportation network, though no significant differences between the two sites was shown.[9]

Muizelaar provided findings from a Dutch online survey that included several components, including examining the impact of nonrecurring events on traffic.[10] Three nonrecurring situations were presented to drivers: crashes, road work, and large events. In the case of crashes, travelers wanted to receive extended traffic information, such as the cause and expected duration. Travelers wanted to be able to make their own route choice from that information. In regard to road work, travelers showed a greater preference toward wanting to receive information about the fastest route. In the case of large events, travelers preferred receiving information that increased their comfort level for accuracy of the information.

CHAPTER 3. TRAVELER INFORMATION FOR NONRECURRING EVENTS STATE OF THE PRACTICE

BEST PRACTICES FOR IMPLEMENTATION

This section summarizes the range of appropriate apps, including their delivery medium, related emerging technologies, and agency practices. Table 1 provides a summary of preliminary implementations reviewed. A few of the implementations were chosen for further discussion in this section. The case studies presented in chapter 5 also address some of these implementations.

Table 1. Preliminary list of candidate implementations.

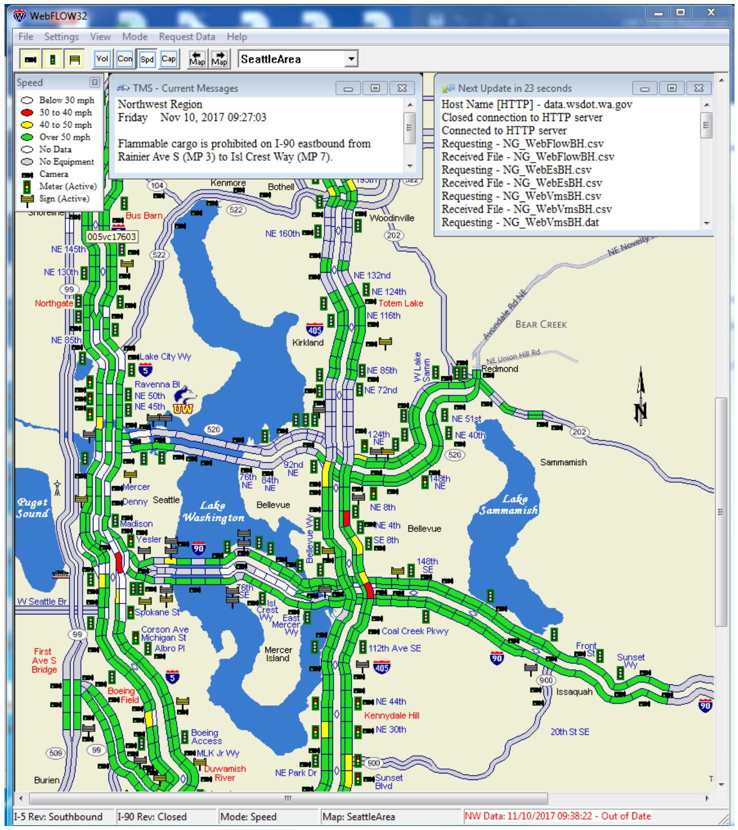
Location	Implementation Technologies
Florida	Florida Department of Transportation 511 and private partnership.[18,19]
Georgia	NaviGAtor™, which is a traveler information Web page.[20]
Lake County, IL	Lake County Program for Arterial Signal Synchronization and trAvel GuidancE (PASSAGE), which is a traveler information Web page.[21]
Minnesota	Minnesota Department of Transportation (MnDOT) 511 mobile app (MN 511), which is a mobile app that provides traveler information.[22]
Pennsylvania Turnpike	PA TURNPIKE TRIP TALK APP, which is a mobile app that provides traveler information.[23]
San Francisco Bay area (through the Metropolitan Transportation Commission)	511 SF Bay, which is a one-stop phone and Web source for up-to-the-minute Bay Area traffic, transit, rideshare, and bicycling information.[24]
Texas	I-35 "Smart Work Zone," which uses DMSs to provide real-time details to motorists on I-35 about travel impacts due to active work zones.
Washington, DC, metro area	Regional Integrated Transportation Information System (RITIS) chat instant messaging tool, which is used by members of the I-95 Corridor Coalition and other interested parties.[25]
Washington	Washington State Department of Transportation (WSDOT) mobile app that provides traveler information.[26]
Wisconsin	511 Wisconsin, which is a traveler information Web page.[27]
Wyoming	Weather Responsive Traffic Management and Rural ITS, which provides road weather information during weather events and applies variable speed limits to improve safety during weather events.

Data Collection Technology

Data collection technology in traveler information system apps is currently applied by both public agency and private sector stakeholders. Public agencies typically use fixed location equipment. Common systems for data collection at discrete locations include induction loop detectors, ultrasonic and microwave detection, and camera systems. Some agencies, in order to reduce costs associated with urban freeway systems, use detection systems for the entire roadway at longer intervals while detecting a typical lane at closer intervals for adequate data resolution. This field detection hardware is connected to a field cabinet, and data transmission to a centralized processing facility is typically achieved with ground-based communications. In older systems, leased and owned copper cable systems are used (i.e., four-stranded phone lines). Conversely, newer systems and those on reconstructed freeways are connected to fiber-optic networks, generally using Internet provider-addressable detection and communications hardware. The traffic data, typically detector occupancy, are processed by the agency, and algorithms are used to generate travel times and congestion limits. This information is typically provided free of charge to media outlets, often with a dedicated information terminal, and by means of websites and mobile apps.

Private sector data collection efforts are typically executed using position data from private mobile devices. These position data are generated by the cellular network and enhanced with wireless connection triangulation and GPS location information provided by the device. The users of these apps agree to the privacy statement and are therefore providing the information in accordance with the privacy policy of the app developer and device vendor, which is typically a cellular network provider. The position data are processed by the app vendor and used to service their product. They are also often sold to service other products.

The extent of the data collection activities in western Washington is indicated by the Seattle, WA, traffic map (see figure 2), which indicates the degree of congestion on the system during the early part of the afternoon peak period. Many of the areas on lesser traveled freeways or urban fringe roadways are depicted in gray, indicating a lack of information due to the areas not being covered by the agency's detection hardware.[28] A similar view, from a Web-based private-sector provider, would show information available throughout the system because users of those mobile apps and mobile devices tied to that data collection system are traveling throughout the system.



Screen Capture ©WSDOT.

Figure 2. Map. Screenshot. Traffic map of Seattle, WA.[(28)]

While ubiquitous mobile device use has provided a platform for traveler information dissemination, app creators must consider integration across all modes of travel and for a wide variety of users.

In the 1990s, traveler information was disseminated using traditional media sources that did not include the Internet, such as television and terrestrial radio, as well as via roadside infrastructure, such as variable message signs (VMSs). As the Internet emerged and information became accessible at home and in the workplace, Web-based portals for traffic information became popular. An example of the type of traffic maps pioneered by agencies such as WSDOT is shown in figure 2.[(28)] This map is still accessed by a large number of users, even on mobile devices, because it is straightforward and provides a consistent display of traffic information. Also, it does not require a lot of data usage, so it downloads quickly.

Traveler information regarding transit operations can also be obtained using mobile devices, but the utility of displays at transit stops and train stations lies in its ability to serve all users, regardless of economic availability of mobile data or the availability of a reliable mobile data connection itself. In the deployment of new bus rapid transit corridors, agencies such as the King County Metro in King County, WA, as well as other operating regional bus systems have deployed ITS infrastructure to provide arrival time displays at transit stops. Even traditional static maps, which are occasionally made interactive with touch-responsive displays in some transit stations, are a useful tool when coupled with a static copy of the schedule.

Mobile Devices

Mobile devices can offer travelers information on every mode of travel, including transit buses, transit trains, intercity and regional rail, and travel times for various modes of travel. One significant advance is the ability of mobile apps to predict travel times for various modes or combinations of modes based on expected traffic conditions. Additionally, the use of mobile devices for determining the availability of parking in a dense urban area or the best choice for a transit connection based on parking availability (commonly used in Germany) is mainstream and serves to reduce congestion in urban areas by eliminating superfluous parking searches.

As digitally available traveler information systems evolve, it remains important for agencies and traveler information providers to provide not only mobile access but also Web-based access on nonmobile devices and access using terrestrial radio and in-vehicle telematics. Each of these systems has a different role and can display information based on the potential for user distraction (e.g., leading mobile devices to fill an important gap between websites and in-vehicle telematics).

Social Media

Numerous large municipalities and several State transportation departments have made extensive use of Twitter™, which is a short-message social media platform that emphasizes networks of followers. Typically, owing to the brevity of Twitter™ messages and their short duration in a user's media feed, agencies use Twitter™ to share information regarding transient events, rapidly changing conditions, and travel advisories. The more static nature of Facebook® and its platform for sharing longer messages and more images is used by certain State transportation departments to support information on the impacts of construction projects, project development, opportunities for public involvement, and the general work of the agency.

Private companies collecting and sharing traffic data have created their own social networks. For example, some apps have created a platform where users can share information with each other. Case study 1 in chapter 5 further addresses some of the social media techniques that agencies are using to reach larger audiences inexpensively while ensuring that the agency's mission and message remain consistent.

Integration with Partners

Partnerships exist between agencies and media outlets, agencies and data suppliers, and agencies and other agencies. Partnerships between agencies and media outlets help agencies improve the delivery of information by broadening their reach, while partnerships between agencies and data suppliers create a new market for agency data and improve the reliability of information with additional and supplemental data from the suppliers. Agencies form partnerships with other agencies in an effort to share information and resources, facilitate coordinated emergency response operations, and ease traveler transition between regions while providing a platform for meeting multi-agency regional objectives in traveler information.

In northeastern Illinois, the Illinois Department of Transportation provides travel time information to media outlets through a dedicated feed option, in addition to disseminating that information through the Great Lakes Regional Traffic Operations Coalition portal (see figure 3).

Screen Capture ©Illinois Department of Transportation and Great Lakes Regional Transportation Operations Coalition partners in cooperation with the University of Illinois at Chicago Artificial Intelligence Lab (Map in screen capture ©NAVTEQ).

Figure 3. Screenshot. TravelMidwest website.[29]

The TravelMidwest website (formerly referred to as the "Gary-Chicago-Milwaukee Corridor" website) provides access to information, including cameras, VMSs, and other data, from multiple agencies across three States (Wisconsin, Illinois, and Indiana), including a toll authority.[29] Other notable interregional efforts to consolidate traveler information and provide a framework for large-scale incident management include the I-95 Corridor Coalition and RITIS, which is a tool designed to facilitate efforts to disseminate traveler information among both managing agencies as well as cooperating agencies.[25]

EMERGING TECHNOLOGIES AND TRENDS

This section highlights the latest approaches and technologies used in traveler information for nonrecurring events. Private sector data and mobile apps are included in the discussion.

Private Sector Data

Agencies have long used hardware that they maintained and operated as a means of collecting traffic data, weather data, and imagery, with the objective of providing information to the traveling public as necessary to manage the system and inform road users of travel times and a range of traffic incidents. The proliferation of mobile devices has enabled private sector entities to collect and quickly disseminate reliable data on vehicle speeds, traffic congestion, and incidents.

Agencies without extensive surveillance and traffic data collection systems are sometimes choosing to forego extensive public investment in those systems and are instead turning to private sector suppliers.

Integration with Vehicle Telematics

In the last 15 yr, on-board vehicle systems with connections to the Internet as well as satellite-based communications systems have become standard equipment in many vehicles. Many cars with GPS-based navigation systems and full-color screens also offer traffic condition overlays on those maps, incident information (including reoccurring and nonrecurring special events), and even navigation system-based dynamic rerouting.

Traveler information systems play an important role in vehicle operations and electric vehicles in particular. The range of an electric vehicle is heavily impacted by operating conditions, and traveler information systems can provide information the vehicle can use to predict the impact of traffic conditions, speed on hills, and even weather conditions to provide accurate determination of range and the viability of alternative routes.

Road Weather Information Systems

Efforts are underway in Wyoming and other States to integrate road weather information from connected vehicles with traveler information systems and current systems that use fixed location weather stations. Part of this development involves the incorporation of feedback from vehicle speed, accelerator position, and inputs from vehicle stability control systems to determine road conditions and the applicability of traveler messages related to inclement weather and deteriorating road surface friction characteristics. These weather-related messages can also promote safety by altering road user behavior with messages.

DISSEMINATION METHODS AND MEDIA

This section focuses on some of the common approaches used to provide traveler information to the public for nonrecurring events. The general methods for establishing and implementing programs for traveler information systems for nonrecurring events are discussed with brief focus on each type of media (e.g., mobile apps, radio, CMSs, HAR, 511). Examples include the following:

- **511 telephone system**: The 511 telephone system is a publicly operated telephone hotline available free of charge to the traveling public. The system primarily disseminates information on crashes, road closures, construction, or other events. The reporting that is provided is more generic (e.g., road work from X date to X date), and daily impacts are usually not reported. The system is most effective when the information is available from a variety of reliable sources, such as road weather information systems (RWISs), closed-circuit television (CCTV), roadside detection (RS-D), and environmental sensing systems (ESSs), among others.

- **DMSs**: Also known as VMSs or CMSs, DMSs can alter the displayed message to provide travelers with important information about nonrecurring events. For example, messages about events can be displayed on a DMS upstream of affected areas and provide alternate routes. Portable DMSs can be strategically placed to provide advance information for planned events or long duration events. Signs are often placed on freeways within a region or corridor, and this may expand to high-speed arterials over the next 10 yr based on industry experts' predictions.[30]

- **Traveler information websites, including 511**: Traveler information websites provide real-time traffic condition reports about information such as work zones, weather conditions, traffic speed, message signs, traffic events, and incident reports. Similar to the 511 telephone system, these websites are publicly operated. They can be accessed via desktop or laptop computer as well as via mobile devices.

- **HAR**: HAR provides free roadway information in particular areas. It is an en-route information source, and users must tune in to a specific channel (using an AM or FM radio band) that is often specified on a roadway sign to obtain information. HAR provides traveler information about road closures, work zones, incidents, alternate routes, and current roadway conditions. Information that is provided is gathered from RWISs, ESSs, RS-Ds, CCTVs, pavement sensors, and other technologies that gather roadway information. One of its limitations is its reliability with its reach due to radio transmission.

- **Mobile apps**: Mobile apps are available for smartphones, tablets, and other portable devices. They are available through private companies and, increasingly, from the public sector through State and regional transportation agencies. Examples include the following:

    - **Private sector**: Mobile apps that are provided through a private company provide travelers with pre-trip and en-route directions and traffic information that are free community-based platforms for road users to share information about local roads.

    - **Public sector**: Public sector mobile apps generally provide camera images of specific incidents as well as their nature and duration. They also generally provide information for other transportation modalities aside from roadways (e.g., ferry and rail service; see the Case Study 1: Mobile Apps section in chapter 5 for an example). Mapping services for these apps are generally integrated with online mapping software.

- **Social media platforms**: Two commonly used platforms include the following:

    - **Twitter™**: This short-message social media platform (i.e., messages are currently limited to 140 characters) emphasizes networks of followers. Typically, owing to the brevity of Twitter™ messages and their short duration in a user's media feed, agencies use it to share information regarding transient events, rapidly changing conditions, and travel advisories. Messages can include hyperlinks to an agency's website for additional information as well as hashtags that allow users to search for or follow only messages that relate to their routes or areas of travel (e.g., a hashtag can be created specifically for a major road work project or for stadium events).[11] Users can share (i.e., retweet) messages at any time, so it is important to post messages with timestamps for nonrecurring events so that outdated messages are not perceived to be current.[31]

  - **Facebook®**: This platform is generally used for sharing longer messages and images. It can be used to provide information on the impacts of construction projects, project development, opportunities for public involvement, and the general work of an agency.

- **Alerts systems**: Alert systems are subscription-based systems available in some regions and metro areas that allow users to sign up to receive emergency alerts and warnings, which may include alerts on major nonrecurring traffic events. These systems often allow users to customize the areas of interest to them, the types of messages they want to receive (weather, traffic, schools, etc.), and how they want to receive them (email, text message, etc.). Information is "pushed" to users, allowing rapid dissemination. Users can then make decisions either pre-trip or en route based on alerts.

- **Radio**: Radio via the AM/FM radio band is a traditional method for receiving travel information. It is easy to access and assists travelers with en-route travel planning. It provides only brief details about events (e.g., the location of a crash).

- **Television**: Television is another traditional method for receiving travel information through the local news media outlets. Similar to radio, it is easy to access, and travelers can use this method before trips. It, too, typically provides only brief details about incidents or delays.

MESSAGE TYPES AND EXAMPLES

This section focuses on some of the common messages and examples used to provide traveler information for nonrecurring events. Table 2 provides a summary of example messages for various types of situations and delivery methods. In addition to the messages, the table provides information about the needs and limitations of the message type as well as usability considerations and sources for further guidance on message design. Note that there are very few, if any, direct sources investigating these needs specifically for nonrecurring event information. Several studies or guidance documents include nonrecurring events along with other types of traveler information, and the table draws from a variety of broader sources (see table 2 for relevant sources).

Table 2. Example messages for various types of situations and delivery methods.

Delivery Method	Example Message	Information Needs	Limitations	Usability Considerations	Guidance
DMS	I-95 NB CRASH; AT RTE 240; EXPECT LONG DELAYS	Problem, location, action, information reliability, and update status	No information on update status or alternative route	Right and left justified preference, no more than six information units per phase, and uppercase letters	For DMS, see references 32–34
DMS	CONGESTION AHEAD/ REDUCED SPEED; 15 MPH	Problem, location, action, information reliability, and update status	No information on update status or alternative route	Right and left justified preference, no more than six information units per phase, and uppercase letters	For DMS, see references 32–34
DMS	WATCH FOR STOPPED TRAFFIC	Problem, location, action, information reliability, and update status	No information on update status or alternative route	Right and left justified preference, no more than six information units per phase, and uppercase letters	For DMS, see references 32–34
DMS	RIGHT LANE CLOSED; 5 MILES AHEAD/REDUCE SPEED	Problem, location, action, information reliability, and update status	No information on update status or alternative route	Right and left justified preference, no more than six information units per phase, and uppercase letters	For DMS, see references 32–34
DMS	ROAD CLOSED AHEAD; FOLLOW DETOUR	Problem, location, action, information reliability, and update status	No information on update status	Right and left justified preference, no more than six information units per phase, and uppercase letters	For DMS, see references 32–34
DMS	ICY SPOTS, NEXT 5 MILES	Problem, location, action, information reliability, and update status	No information on update status or alternative route	Right and left justified preference, no more than six information units per phase, and uppercase letters	For DMS, see references 32–34
DMS	ICE ON BRIDGE SLOW	Problem, location, action, information reliability, and update status	No information on update status or alternative route	Right and left justified preference, no more than six information units per phase, and uppercase letters	For DMS, see references 32–34

Delivery Method	Example Message	Information Needs	Limitations	Usability Considerations	Guidance
DMS	PERIODIC RAIN REDUCE SPEED USE HEADLIGHTS	Problem, location, action, information reliability, and update status	No information on update status or alternative route	Right and left justified preference, no more than six information units per phase, and uppercase letters	For DMS, see references 32–34
DMS	CAUTION FLOODING AHEAD	Problem, location, action, information reliability, and update status	No information on update status or alternative route	Right and left justified preference, no more than six information units per phase, and uppercase letters	For DMS, see references 32–34
DMS	HURRICANE WARNING SEEK SHELTER	Problem, location, action, information reliability, and update status	No information on update status or alternative route	Right and left justified preference, no more than six information units per phase, and uppercase letters	For DMS, see references 32–34
DMS	METER ON	Problem, location, action, information reliability, and update status	Only stating event, with no time, location, or preferred action; no information on update status	Right and left justified preference, no more than six information units per phase, and uppercase letters	For DMS, see references 32–34
DMS, mobile app	ALL LANES CLOSED	Problem, location, action, information reliability, and update status	No information on update status or alternative route	Right and left justified preference, no more than six information units per phase, and uppercase letters	For DMS, see references 32–34
511 website	I-70 Westbound/ Eastbound Georgetown to Genesee (Mile marker 228–259). High wind advisory.	Problem, location, action, information reliability, and update status	No information on update status or alternative route	Website design considerations (color, contrast, placement, etc.)	None

Delivery Method	Example Message	Information Needs	Limitations	Usability Considerations	Guidance
511 website	Motorists are advised of possible heavy smoke on Interstate 10 east and west bound in Santa Rosa county. Use caution.	Problem, location, action, information reliability, and update status	No information on update status or alternative route	Website design considerations (e.g., color, contrast, and placement)	None
Social media	***TRAVEL ALERT ***High winds, blowing dust, and limited visibility	Problem, location, action, information reliability, and update status	No information on update status or alternative route	None	None
Social media	Magnitude 4.8 earthquake followed by two small jolts strike east of Fresno	Problem, location, action, information reliability, and update status	No information on update status	None	None
Social media	Downed trees are causing issues on I-277 in Charlotte. Crews working to clear road before evening rush hour.	Problem, location, action, information reliability, and update status	No information on update status or alternative route	None	None
Mobile app	Heavy Snow	Problem, location, action, information reliability, and update status	None	Legibility and size of text while driving	None

Table 3 in appendix A provides a taxonomy of message types that can be used for traveler information about nonrecurring events. It provides information and messages where possible, although it is not complete due to a lack of examples or information in the literature for some situations. The table indicates the event type, messages that can be delivered at various times (before an event, at the time of an event, after an event has begun, etc.), the delivery method, and example messages. Events addressed include incidents such as work zone and weather-related events. The information contained is based on current practices. It should be noted that there is a desire for information about when a current event will end (including those that are more difficult to predict, such as unplanned events), although that is not common practice.[11] Table 3 can be used as a tool to plan messaging strategies for a wide range of potential nonrecurring events.

MESSAGING STRATEGIES

Earlier sections of this report addressed user information needs, dissemination methods, and message examples. These topics can be synthesized to develop high-level strategies and best practices for dissemination of information for nonrecurring events.

Planned Events

While rapid dissemination of information for unplanned events is key, planned events allow an agency some time to prepare and inform travelers in advance of the event. Information can be targeted toward individuals who are planning to travel to an event such as a concert or festival, or it can be targeted to other travelers who will be affected by the event. Advance information can be provided in a variety of ways. For example, press releases and other free media can be used to broadly share information through television and radio, and billboards and other print media can also be developed. Additionally, multiple agencies can coordinate to maximize outreach. Advance information can also be disseminated on roadways. For example, DMSs can be used to alert drivers to upcoming road work in the area. If a fixed DMS is not present in the to-be-affected area, fixed signage or a portable DMS can be moved to the area on a temporary basis.

Planned events also provide traffic managers with a greater opportunity to provide travelers with solutions. The public can be encouraged to take alternate modes of transportation or alternate routes. For example, detour signage can be set up to route drivers around road work events. Where planned events occur with some regularity (e.g., near a stadium), dynamic devices such as trailblazer signs, lane control signs, and blank-out signs can be installed to aid in providing traveler information.[35] The Federal Highway Administration (FHWA) notes that current practices for planned events tend to be event specific, so there is no universal set of best practices to providing traveler information for planned events.[36]

Matching Traveler Information Needs and Expectations

Nonrecurring events may lead to unexpected congestion, delays, and detours while inconveniencing and frustrating travelers. Whereas recurring congestion (e.g., urban commute traffic) is often predictable and somewhat consistent over time, nonrecurring congestion may be much less predictable. Travelers want information that helps them understand the nature of a nonrecurring event and how to minimize the impact of the event on their travel. Information provided to travelers before their trips or early enough in their trips so that they can take alternate routes can lead to time-savings benefits for travelers as well as broader traffic flow benefits.[11,37] Even if the information does not result in any concrete benefits, such as time savings, simply understanding the reason and the scope of the unexpected travel disruption provides a stress-relieving benefit to drivers.[30,33]

When choosing a route or considering diverting from a route due to an unexpected event, drivers may want to know the delay or disruption it will cause, availability and time savings of alternate routes, cause of the delay, and when the event (or the resulting congestion) is expected to end.[11] When traveling in an unfamiliar area, drivers may also want turn-by-turn directions for the alternate route, a map of the route, and exit numbers where they can leave and return to the original route.[11] Commercial drivers have special concerns regarding route diversion because of the potential for commercial vehicle restrictions (height, hazardous materials, etc.) and other concerns such as narrow or steep roads. They could benefit by receiving advanced notice of planned events and information about height and weight restrictions on available routes.[11]

The affected locations by a nonrecurring event should be described as specifically as possible so travelers can tell if their planned route is affected. It is important that travelers receive accurate and current information. One solution would be to add timestamps to messages.[31]

Nonlocal Versus Local Travelers

Nonlocal drivers, such as tourists, business travelers, and long-distance through drivers, differ from local drivers in some important ways. Nonlocal drivers are likely to be less familiar with area roads, alternative route options, transit alternatives, planned events, congestion patterns, and sources of traveler information. They may benefit from en-route information such as DMSs, especially when clear route guidance is provided.[11] This is especially important for areas with a large percentage of unfamiliar drivers. For example, Anaheim, CA, has a network of arterial DMSs to provide information to tourists around Disneyland®.[30]

Nonagency Traveler Information Context

Prior to the advent of the Internet, transportation agencies and local television and radio stations were largely the only providers of traveler information. In recent years, however, the Internet has enabled the private sector to enter this domain. Websites and apps allow drivers to automatically plot the fastest route to their destination, view traffic conditions and delays, select alternate routes and alternative transportation modes, and identify the cause and location of a nonrecurring event. These platforms can be used pre-trip or en route. Some stand-alone navigation devices also provide real-time traffic information. Such systems are powerful traveler information tools and popular with travelers. Similarly, travelers may have access to traveler information from other agencies, including local or State jurisdictions, transit agencies, etc. It is important for transportation agencies to consider the various information sources available to drivers from private sector sources, as well as other public sector sources, when considering how best to provide traveler information within the broader information context available to travelers. Partnerships with other regional agencies may provide benefits in terms of traveler information consistency, cohesiveness, geographical range, and multimodal coverage within the broader framework of integrated corridor management principles.[38]

Maximizing Use and Benefits of Traveler Information

Traveler information can only be beneficial to travelers if they know of it and use it. Studies have found that travelers are often unaware of information available to them through 511 systems, mobile apps, HAR, and other sources.(11,33) Informing the public of available options and potential benefits may increase usage. Presenting information on multiple platforms may help as well. For instance, information about a major nonrecurring event could be posted on social media, 511 websites, and mobile apps to maximize the likelihood that travelers see the information. To reduce the likelihood of receiving redundant or irrelevant information, users may be able to customize the types of messages that are of interest to them and their preferred notification settings. Finally, the availability and popularity of technologies and information platforms can change quickly. For example, since the first iPhone® was unveiled in 2007, smartphones have proliferated. It is important to develop websites and apps that are optimized for current mobile devices as well as to keep pace with the public's changing technology preferences.

EVALUATION AND ASSESSMENT OF THE PUBLIC'S USE AND UNDERSTANDING OF TRAVELER INFORMATION

There are a variety of methods to assess the public's use and perception as well as the effect of traveler information systems. Traditional methods have included call statistics, website hits, and satisfaction surveys. Although helpful, these methods have limitations regarding understanding the effect of traveler information on travel behavior and decisionmaking. For example, 511 calls may spike if an incident occurs but may not result in many people adjusting their travel route, especially if there is low confidence in 511 accuracy or operation. Similarly, a satisfaction survey may provide information about the overall likeability of information sources but not the overall use or effects on travel behavior. In a previous study on real-time travel time signs, it was found that individuals liked having the signs present but generally did not use them to adjust their trip behaviors (often due to lack of alternative route options or information).(33,39) Consequently, assessing the effect of traveler information on trip behavior requires alternative approaches used in combination with these more traditional methods.

Based on prior experiences and findings, a "toolbox" method could be used to evaluate traveler information systems (specifically nonrecurring events messaging).(6) This approach combines a variety of focused, targeted, and low-cost methods such as targeted surveys, focus groups, driver diaries, and interviews that evaluate different aspects of a traveler information program in a particular area. It is also desirable to use a combination of methods due to the large variety of dissemination methods, traveler characteristics, and information types. Findings from these methods can then be combined to generate a profile of overall system effectiveness, especially with respect to its effect on trip behavior.

The toolbox should consist of several components that can be inexpensively adapted to a particular area or region and can provide insight into the effectiveness of a traveler information program. These practices could be incorporated into a funded evaluation program where outside expertise can be brought in to execute and properly interpret the findings. The following list provides examples of methods that can be used:

- **Focus groups targeting particular travelers**: Questions should be tested and developed on populations of interest.

- **Traveler logs or diaries**: This method focuses on effects on actual travel behavior and looks for shifts in planned route/mode, trip characteristics (occupancy, chaining, etc.), pre-trip and en-route behavior, outcomes, and perceived benefits. This method should be used in a limited manner to supplement focus group findings. In fact, focus group participants can also be invited to participate in a traveler log study.

- **Targeted surveys**: A combination of Web-based surveys and mail-outs should be used.

- **Interviews**: Due to the resource-intensive nature (one interviewer per participant at a time), this method should only be used for a focused follow-up to some responses or statements collected in earlier phases through surveys.

The methods described should be used in combination to gather a variety of information. Some methods are more suitable for certain types of information (e.g., interviews and focus groups are useful for gaining insight into particular issues the public may have with hypothetical systems or test implementations, while traveler logs can be a validity check on how frequently people really change trips and based on what type of information source they use before changing trips). In order to develop a profile of traveler information effects on trip behavior and traveler information usage in an area, the following information should be collected:

- Traveler type (commuters, elderly, etc.).

- Information type (travel time, congestion levels, incident information, weather, work zone, location, etc.).

- Information source or media used (mobile apps, websites, radio, TV, signs, etc.).

- Temporal information need (e.g., pre-trip, near trip, or en route).

- Traveler perception of quality, accuracy, reliability, and availability of information.

- Information comprehension.

- Information effect on travel behavior.

- Likeability/satisfaction with the traveler information.

- Frequency of use.

- Traveler perception of risk (e.g., distraction of mobile devices).

- Crash data.

CHAPTER 4. GAPS BETWEEN PRACTICES AND USER NEEDS, CHALLENGES, AND ISSUES

This chapter highlights some of the common challenges and issues that practitioners face with respect to implementing traveler information dissemination strategies for nonrecurring events. Every implementation and messaging strategy faces a unique set of circumstances and constraints (geography, topography, budget, rationale for implementation, etc.), and guidance on this topic cannot be a one-size-fits-all solution. Rather than providing prescriptive guidance, this chapter focuses on identifying options and practices that can be adapted to the needs of a particular situation, guiding the practitioner to areas that are needed most by users.

Features of an ideal system according to travelers and where there is agreement with agency practices include the following:(6)

- The system should be targeted, local, and relevant to the consumer and possibly based on GPS-enabled cell phones or vehicles so that relevant, location-based information is provided.
- The system should be easy to access and use, including when en route.
- The system should provide clear, concise, and trustworthy information that is accurate and reliable.
- The system should include information on nonrecurring events that may drastically affect routes, such as special events, construction/maintenance, or emergencies.
- The system should use technologies that are widely available to everyone and easily implemented (e.g., radio).

These features were recommended by travelers who participated in that study and are not necessarily complete or recommended by the authors of this report.(6) For example, weather is not included as information that would affect routes, yet it would be recommended to include as part of an ideal system. In addition, actionable information should be included but was not mentioned by participants. Surprisingly, features that are considered less effective by both agencies and the public are still in wide use today (e.g., HAR).(6)

Similarly, Higgins, et al. found that the following features were preferred by the traveling public:(11)

- The system should indicate the length of expected delay on original route.
- The system should recommend a specific alternate route.
- The system should provide the travel time on both original and alternative routes.
- The system should indicate the time when the roadway event is expected to be resolved.

- The system should provide exit numbers for unfamiliar alternative routes and ideally directions with a map.
- The system should provide options for radio, DMS, and GPS (with some indication of a desire for text messages and mobile apps).

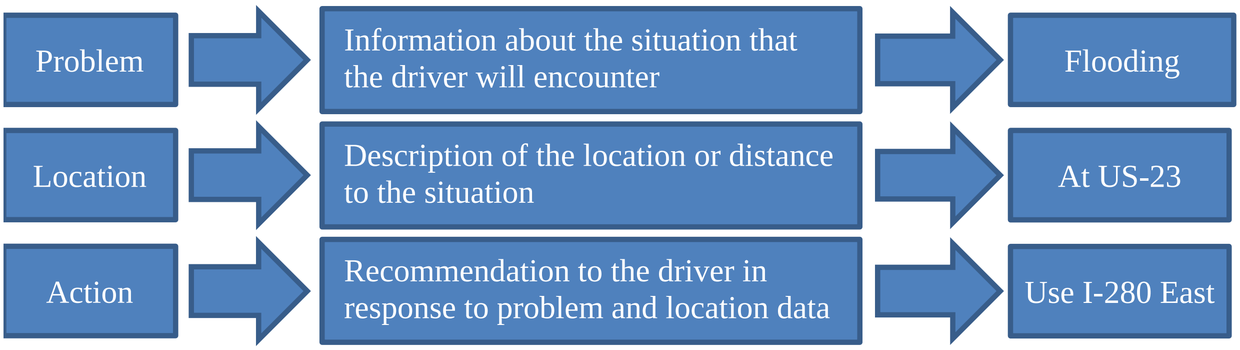
There are also some notable examples of where perceptions between the public and the agencies do not match. It is these instances that are of interest to transportation departments, as they point to features where resources are needlessly being expended or where features might need considerable improvement. Some examples of information sources that may be perceived to have limited effectiveness or where there are disagreements among the public and agencies about effectiveness are as follows:

- **HAR**: Research by Robinson et al. found that both agencies and the public agree that HAR has limited effectiveness.(6) Of the methods used by agencies, this was deemed the least effective method of getting traveler information to the public. The public agrees, as focus groups and surveys indicated that an overwhelming majority of people do not trust or use HAR.(6) In addition, Higgins, et al. found similar issues with HAR use by the public within Wisconsin.(11) However, it should be noted that Al-Deek suggested that HAR has the potential to provide benefits to drivers.(40) Survey responses showed that only 24 percent of motorists have used HAR, while only 57 percent were aware of HAR.(6) Although these numbers indicate a low usage rate, 87 percent of respondents believed that the service should be continued, while 84 percent said they would use HAR in the future. Survey results indicated that HAR could also be a valuable tool for providing emergency information, as 87 percent of respondents said they would use it in emergencies. Despite these mixed impressions, HAR is widely available to en-route drivers using their car radios and may be considered worthwhile as part of a traveler information toolbox, particularly if some improvements are made (e.g., more frequent information updates or a timestamp to indicate how recently the message was updated).
- **Social media and mobile apps**: Traveler information program features using social media and mobile apps are receiving increased attention from agencies, as they are considered effective. From a traveler information program perspective, these features are perhaps the most "cutting edge" in terms of state of the practice; however, the long-term viability remains to be seen. From a public perspective, as of 2012, very few people had been using social media and mobile apps to receive traveler information (although that has likely increased dramatically since).(6)
- **511 phone systems**: Many agencies have implemented or are moving toward using 511 phone systems, as they are considered to be highly effective, so much so that FHWA sponsored the 511 deployment initiative along with other entities.(6) However, at the same time, State legislatures have been moving to ban cell phone use while driving, and the public's mindset is changing in the same direction.(6) This may explain why a review of survey results indicates that making a 511 phone call is not deemed a particularly effective method of getting en-route traveler information.(6) This may be the result of a conflict between developing State laws and public perceptions targeting cell phone use and the desire for en-route travel information. The overall aim for an effective traveler

information system should be alignment between the agency's goals and the public's needs/wants. It should be noted that the 511 phone system could still be used by passengers.

There are several potential gaps between how systems are being operated and user needs that cut across dissemination methods.[(6)] Some of these issues are due to implementation or terrain impediments, while others are related to technology that has not been developed but is needed.

The problem, location, and action (PLA) method is often used to define basic DMS message content. An example of PLA that was inspired by Lichty et al. is presented in figure 4.[(41)]



Source: FHWA.

Figure 4. Flowchart. PLA example.

The PLA structure can be broken down further to include message elements that provide the travel time or may use the word "delay" to let travelers know how severe a situation is. This can assist them with understanding the expectations about the specific trip or make alternate travel plans. Example message elements that provide information on the effect on travel include "X Min Delay" or "Major Delay." The audience for the action might also be specified by including the message element "X Metro Area" or "Eastbound traffic." There also may be message elements that provide travelers with a good reason to follow the action, such as "Avoid X Min Delay" or "Best Route to I-95," which indicates that following the advice on the DMS could lead to time savings or a safer traveling situation. The following gaps intersect with these different components to a message and highlight issues with each:

- **Potential gap 1—location**: There are some locations (e.g., rural areas or mountainous regions) where information about major events (including weather) and related emergencies need to be projected at a great distance. For example, some areas within Missouri have grappled with the issue that if there is a major accident or inclement weather that forces the shutdown of a corridor, then drivers need to be informed upward of 100 mi out in order to properly route around that town (where there are not viable alternatives once a driver enters that corridor).[(37)] Similarly, location-sensitive information needs to be relevant. In other words, travelers do not want to be inundated with information about an event hundreds of miles away. Yet, there is a balance between information about near nonrecurring events as well as messages about distant nonrecurring events that can affect routing or trip planning. Location may also mean providing relevant information at key decision points, such as a freeway entrance.[(34)]

- **Potential gap 2—timeliness**: In addition to being mindful of distance, timeliness of messages is also important to travelers. For example, providing warning messages about the potential for ice after cars are starting to spin out on an interstate would not be considered helpful. Timeliness is a challenge for agencies because gathering and validating incoming information about quickly changing conditions (weather, emergencies, etc.) is very complex and difficult. Connected vehicle technology may help with this due to enhanced localized information from various sources being transmitted back to the TMC. In addition, greater social media usage on mobile devices and two-way messaging (from the TMC to the traveler and from the traveler to the TMC) will also help close this gap.

- **Potential gap 3—alternative route or action information**: A common complaint by many travelers is the lack of alternative route or action information. In some cases, this depends on the local terrain, as there may not be any alternative routes to offer as guidance. Other times, there may be jurisdictional issues between the entities managing the highways and the local roads. Regardless, system efficiency would seem to benefit from giving travelers alternative routes or alternative actions to take in the event of a nonrecurring event. For example, in Nevada, agency representatives[1] noted that compliance of truck drivers to reroute or delay a trip may result from not giving them a suitable alternative when providing high wind warnings. One possible approach that the agency representatives are interested in pursuing is partnering with local businesses and offering parking facilities for truck drivers to take a break until the dangerous wind conditions subside. If these alternatives are given, then proper messaging is a vital part of success.

Although these gaps focus on structural and operational aspects, improper input into messages or dissemination practices could negatively impact travelers' decisionmaking.

[1]Phone interviews of (Director of Nevada Department of Transportation's Freeway & Arterial System of Transportation and District II Manager for Nevada conducted by Westat on February 1, 2016.

CHAPTER 5. CASE STUDIES

When nonrecurring events cause disruptions to a roadway, from short delays to complete road closures during a peak travel period, it is beneficial to provide road users with information from multiple sources. Travelers may first perform a visual assessment of the situation (e.g., a long line of vehicles approaching an intersection exit ramp or slow-moving vehicles covered with snow and ice proceeding in the opposite direction). Secondary information that they may receive includes roadside DMSs, which can display a limited number of characters in a multi-screen message or an announcement on a terrestrial commercial radio. However, these types of information are typically limited and often nonspecific. Tertiary information generally includes detailed, incident-specific information (e.g., information presented on mobile apps or websites). For example, in an urban area, intended destinations and reliability expectations vary so greatly that road users may desire specific and detailed information, including congestion limits, the condition of alternate routes, and even comparative travel times. This information is too complex and detailed to include on a DMS. Consequently, several media outlets should be used in a coordinated effort to get the necessary information to the user at the right time. For example, a comprehensive system can be coordinated within a mobile app as well as across various components of an ITS system.

In each of the following case studies, the authors examine the use of a medium for providing traveler information as well as its impact in several situations. Delving deeper into a particular medium within a specific context in such a case study approach can provide the audience with useful insights into implementation challenges, as well as useful potential solutions. The examples given below were chosen due to their novel approaches to challenges that other locations may encounter with the hope that they can provide useful lessons learned.

CASE STUDY 1—MOBILE APPS

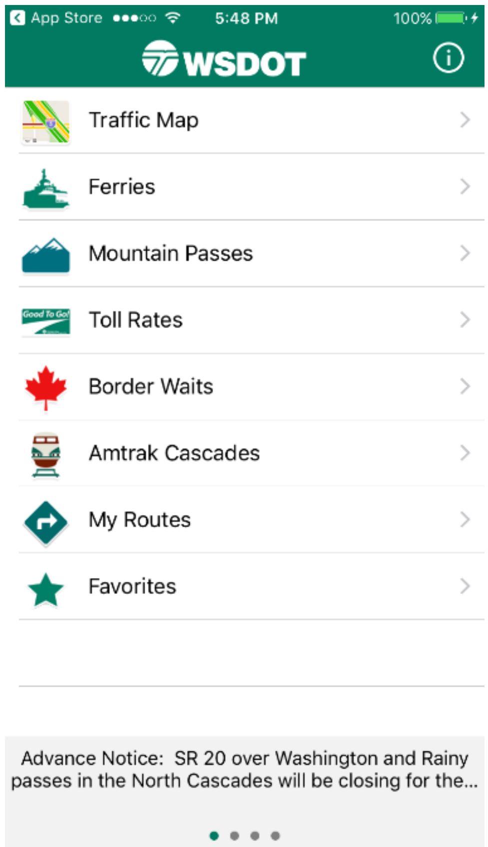
Road user decisionmaking is aided by specific information regarding the nature of the disruption and its anticipated impact. That impact can be expressed in terms of time, restricted access, or distance. For exceptionally complex disruptions, providing immediate information about the impact the disruption will have is sufficient to spur the use of mobile apps and other traveler information systems in making a decision. The user decisionmaking process, which typically assesses the risk of further disruption related to the impact, is generally dictated by the hope of minimizing delays and safety risks by choosing the least disruptive option, which may include proceeding on the planned route.

The ease of access to the Internet by means of mobile cellular devices has revolutionized how the traveling public obtains and interacts with information and the agencies providing it. While traditional traveler information outlets, such as HAR, terrestrial and satellite commercial radio, VMSs, and even variable warning and speed limit signs retain broad application to all travelers, the use of mobile apps enables users to obtain a personalized insight into conditions that can affect their travel.

Numerous agencies, including both State transportation departments and regional transportation agencies, have released mobile apps for traveler information for all modes of transport.

Additionally, private sector apps display information concerning congestion levels and even cameras sourced from public agency data.

Apps from MnDOT, the Georgia Department of Transportation, and WSDOT (see figure 5) allow immediate access to camera images from roadside surveillance systems, integration with information from mapping services to view traffic conditions, and the ability to instantly learn about the nature and duration of incidents reported in the app.[22,42,26] These incidents can include a variety of disruptions, such as sporting events, parades, traveling dignitaries, transient road work, and crashes.

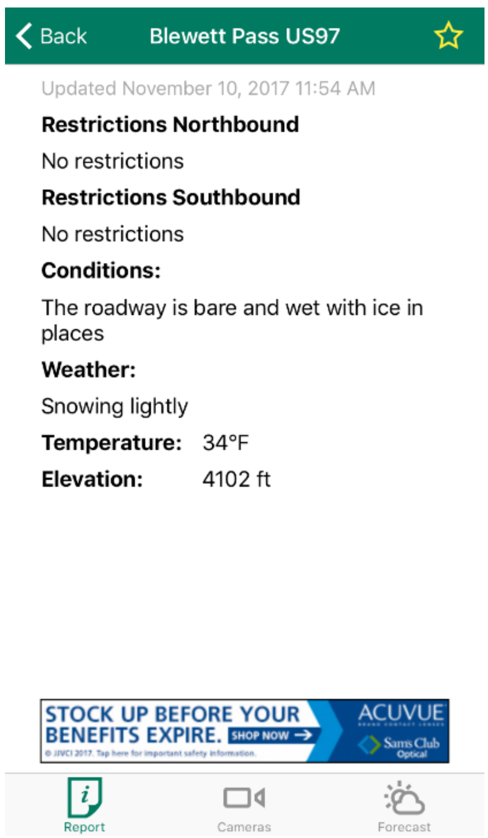


©WSDOT.

Figure 5. Screenshot. WSDOT mobile app home screen.[26]

In Washington, due to the complexity of the transportation network, an effort was made to incorporate a variety of traveler information systems, even across modes, into a single source. In addition to roadway travel information, WSDOT provides information on the ferry system (used by walk-on passengers)—the largest in the United States—and provides the ability to make vehicle reservations using a mobile-optimized external site. It also provides information on the Amtrak Cascades® intercity regional rail service. Additionally, WSDOT uses the app interface as a platform for its efforts to disseminate information using social media.[26] WSDOT has made extensive use of Facebook® and Twitter™, particularly with regard to reporting incidents and the progress associated with clearing those incidents. WSDOT's Twitter™ feed is also used to advise road users of incidents related to snow removal, avalanche control, large gatherings such as sporting events, and weather-related road conditions. Oftentimes, the social media messages include photographs that provide a comprehensive overview of what to expect, which is of great use to users. For example, photographs of a flooded roadway with submerged vehicles are a much greater deterrent than a DMS with a message regarding roadway flooding ahead.

The WSDOT app also features a traffic map, with mapping and congestion information sourced from Google®.[26] Through the map, users can view nearly live camera images from throughout the State, including a video feed in select locations. Information on the mountain passes, including current weather conditions, traffic restrictions, and planned closures, is also disseminated (see figure 6). It is key information for east-west commerce in the State, particularly for freight. WSDOT's rural ITS infrastructure such as the sign on I-90 over Snoqualmie Pass (see figure 7), correlates with the information disseminated using the mobile app and social media, ensuring consistency in messaging.



©WSDOT.

Figure 6. Screenshot. WSDOT mobile app display.[26]

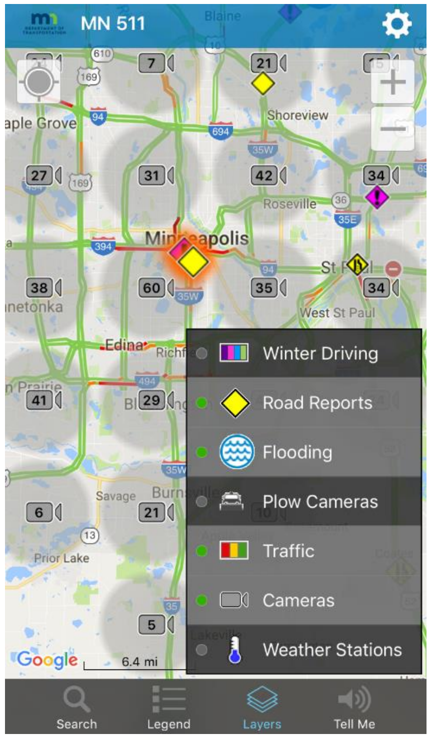
©WSDOT.

Figure 7. Photo. WSDOT DMS on I-90 at Snoqualmie Pass.

The MN 511 app focuses on urban freeway traffic conditions and rural roadway status.(22) It also provides still shots from camera feeds for the entire State. The flexibility of the MN 511 mobile app and users' abilities to turn layers on and off allows them to obtain information specific to the disruption in question. Simplification of the user interface (see figure 8) with easy-to-understand layer control allows users to add information until the desired detail is reached so that they can make a decision at the earliest possible and least complex stage of the interface. The app also allows users to toggle different layers to customize the details shown (see figure 9).

Screen Capture ©MnDOT (Map in screen capture ©Google® Maps™).

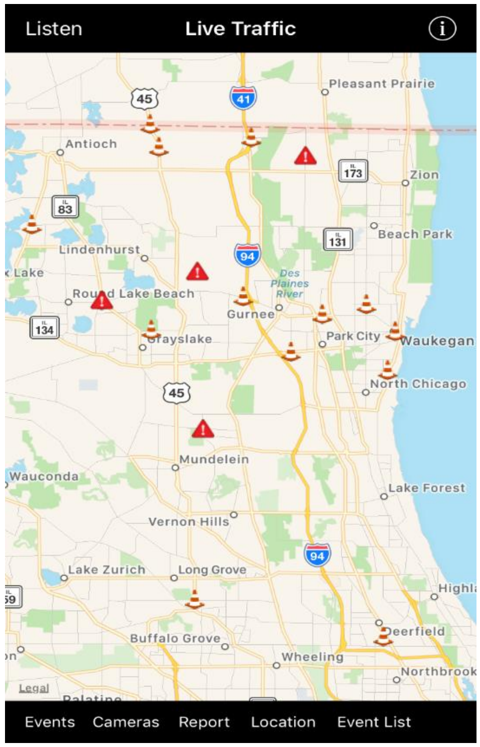
Figure 8. Screenshot. MN 511 mobile app layer control view 1.(43,22,19)



Screen Capture ©MnDOT (Map in screen capture ©Google® Maps™).

Figure 9. Screenshot. MN 511 mobile app layer control view 2.[(44)]

Bridge and toll road authorities as well as county-level transportation departments are producing apps to provide traveler information. The Lake County PASSAGE app (see figure 10), which was produced by the same department within Lake County PASSAGE that manages traffic signal operations in Lake County, IL, provides an interactive map that prioritizes traffic incidents and road work.[(45)] That app as well as another produced by the Virginia Department of Transportation (VDOT) also provide a textual means of accessing information on incidents through an incident list and Twitter™ feed, respectively.[(46)]



©Lake County PASSAGE.

Figure 10. Screenshot. Lake County PASSAGE mobile app.(45)

CASE STUDY 2—COMPREHENSIVE RURAL ITS

In areas where cellular network coverage is problematic and/or driver distraction can lead to high-speed crashes, such as rural freeway networks, providing users with easy access to critical information is a primary concern for agencies. This case study describes one such example in Wyoming. It was recognized that rural traveler information was a means of ensuring public safety and possibly saving lives. As such, the State sought to develop a rural ITS network to support weather-related traveler information systems covering primary highways throughout the State. It developed its Weather Responsive Traffic Management System, which receives data from weather stations and condition reports from maintenance employees using a mobile app hosted on a tablet.

The Wyoming system disseminates information to users primarily through the rural ITS infrastructure in direct and indirect methods. The rural DMS system is used to advise of road closures, inclement weather, and speed reductions by providing direct information to the motoring public. The variable speed limit systems on I-80 and State Highway 28 provide indirect information, an implicit indication of hazardous conditions by means of a reduced speed limit. In most cases, traffic volumes are low enough that users can calculate the extent of the impact of the weather-related disruption by simply adjusting their arrival time expectation based on the revised speed limit. While inferred, the adjustment in speed indicates both the nature of the incident (visible to the user) and the impact (a reduction in expected travel speed, leading to a later arrival).

Typical rural ITS apps tend to focus more on hazards due to nonrecurring conditions and less on disruptions due to incidents related to those conditions. As noted in chapter 2, when a decisionmaker is in a potentially stressful situation (e.g., a dangerous weather event), that person is less capable of handling complex tasks (including making calculations or logical inferences). Therefore, providing clear, direct, and concise information is preferred.

CHAPTER 6. CONCLUSION

Traveler information for nonrecurring events is a vital component to the effective functioning of any transportation system. Timely, correct, and clear information is most needed in situations where unexpected or unusual events occur. These events stress the transportation system the most as well as the traveling public who have to make decisions often based on incomplete or outdated information.

Traveler information for nonrecurring events has evolved significantly in recent years. While agencies continue to use traditional dissemination methods, such as DMSs, HAR, and 511 websites, the available tools have expanded to include mobile apps, social media platforms, and text/email alerts. In the near future, it is hoped that connected vehicle technology will provide personalized, real-time traveler information directly to travelers in their vehicles. Currently, private sector websites and apps provide users with valuable real-time routing, congestion, and event information. While the availability of media drastically expands the toolbox from which traffic managers can draw, it is important to implement information approaches in ways that meet the needs and desires of travelers as well as the needs and limitations of agencies. Key findings and recommendations from this project are as follows:

- Planned and unplanned events necessitate different information strategies. For example, information about events planned in advance can be disseminated early to alert the public. Press releases, news coverage, paid media, DMS messages (including portable DMSs placed at relevant location), emails, and other media can be used. Information about unplanned events should emphasize dissemination methods that can reach travelers as quickly as possible.

- Concrete information should be provided for nonrecurring events. Travelers want to know the nature of the event, the delay or disruption it will cause, and availability and time savings of alternate routes. The affected locations should be described as specifically as possible. Travelers also want to know that the information they receive is accurate and current.

- The audience must be considered. Local travelers and commuters are likely to be familiar with an area's roads and options to seek information about traffic and events. Nonlocal travelers (e.g., tourists and long-distance travelers) may not be familiar with area roads or options for traveler information. Commercial vehicle drivers often acquire relevant information from other commercial vehicle drivers via CB radio.

- Nonagency traveler information should be considered. Radio, television, mobile apps, and websites are widely available and popular with travelers. A traveler information strategy should be developed that considers and complements the various resources available to travelers.

- Where applicable, users should be allowed to personalize the information received. Travelers want information that is relevant to them; irrelevant information is likely to be a nuisance and may reduce usage. Where possible, users should be allowed to choose to receive information that is customized to their location, route, or general areas of interest. This is particularly important for push notifications such as text messages.

- Resources available to the public need to be publicized. The general public is often unaware of the traveler information resources available to them. Informing them of available options and potential benefits may increase usage.

- Travelers may have different preferences for how they like to receive information, so they should be provided information on multiple platforms.

- Traveler information partnerships should be considered. Partnerships with public or private sector organizations can lead to improvements in traveler information data collection and dissemination, improve consistency of information, and expand geographical coverage and audience.

- The availability and popularity of technologies and information platforms can change quickly. It is important to keep pace with the public's changing preferences.

Travelers routinely mentioned the need for information about nonrecurring events that is helpful and easy to access.(33,6,34) There are several areas of research that would benefit from understanding the needs of the public, the transportation system, and the intersection of the two, which would result in optimal decisions being made to adjust to nonrecurring events, such as the following:

- User limitations and decisionmaking in stressful situations (especially emergencies and evacuations).

- Most effective formats and content to convey messages regarding a range of nonrecurring events.

- Most effective dissemination methods, (e.g., social media and in-vehicle devices).

Future research should focus on determining what information from nonrecurring events will help the traveling public make the most effective and safest travel decisions.

APPENDIX A. TAXONOMY OF MESSAGES AND USES

A goal of the current study was to provide a list of representative messages for nonrecurring events that can be used for subsequent testing and guidance. The following table provides example messages for a range of events, as well as considerations of message timing in respect to the event and delivery method. Example messages were changed or tailored to be generic for the purposes of this table. There are cases where there is no information beyond the event type of specific event. These have been left in the table for the purposes of being comprehensive and in respect to the original goal of providing a range of considerations for testing. Example messages can be created for these categories for subsequent testing.

Table 3. Example messages for nonrecurring events.

Type of Event	Specific Event	Type of Information Presented in Relation to Event Timing				Delivery Method	Example Message
		Hours Before Event	Minutes Before Event	At Time of Event	Minutes After Event Started		
Incident	Crash	—	—	Incident occurrence (location, lane closures, etc.)	Incident occurrence (location, lane closures, etc.)	DMS	I-95 NB CRASH; AT RTE 240; EXPECT LONG DELAYS
Work zone	Speed management	Awareness of the presence of work zones along a route	Initial/ advisory speed control	Regulatory speed	Regulatory speed	—	CONGESTION AHEAD/REDUCED SPEED; XX MPH
Work zone	Queue management	Awareness of the presence of work zones along a route, departure time, and route selection	Initial queue warning	Specific speed/ merging action	Specific speed/merging action	—	WATCH FOR STOPPED TRAFFIC
Work zone	Lane configuration/ closure	Awareness of the presence of work zones along a route, departure time, and route selection	Initial notice of lane closure/ configurations	Specific merging/ lane tracking	Specific merging/ lane tracking	DMS	RIGHT LANE CLOSED; X MILES AHEAD/REDUCE SPEED

Type of Event	Specific Event	Type of Information Presented in Relation to Event Timing				Delivery Method	Example Message
		Hours Before Event	Minutes Before Event	At Time of Event	Minutes After Event Started		
Work zone	Lane shift	Awareness of the presence of work zones along a route, departure time, and route selection	Initial notice of lane configurations	Specific lane guidance	Specific lane guidance	DMS	—
Weather	Snow	Awareness of the presence of work zones along a route, departure time, and route selection	Alert to upcoming condition; route change	Advisory or regulatory speed	Advisory or regulatory speed	Mobile app	Heavy Snow
Weather	Intermittent icy spots	—	—	—	—	DMS	ICY SPOTS, NEXT X MILES
Weather	Icy roads	—	—	—	—	DMS	ICE ON BRIDGE SLOW
Weather	Rain	Departure time	Initial/advisory speed control	—	—	DMS	PERIODIC RAIN REDUCE SPEED USE HEADLIGHTS
Weather	Wind/high wind	—	—	—	—	511 website	I-70 Westbound/ Eastbound Georgetown to Genesee (Milemarker 228–259). High wind advisory.

Type of Event	Specific Event	Type of Information Presented in Relation to Event Timing				Delivery Method	Example Message
		Hours Before Event	Minutes Before Event	At Time of Event	Minutes After Event Started		
Weather	Fog/low visibility	—	—	—	—	Social media	***TRAVEL ALERT ***High winds, blowing dust, and limited visibility
Weather	Flooding	—	—	—	—	DMS	CAUTION FLOODING AHEAD
Weather	Hurricane	—	—	—	—	DMS	HURRICANE WARNING SEEK SHELTER
Weather	Full roadway closure	—	—	—	—	DMS, Web app	ALL LANES CLOSED
Planned special event	Detours	—	—	—	—	DMS	ROAD CLOSED AHEAD; FOLLOW DETOUR
Planned special event	Traffic signal control	—	—	—	—	—	—
Planned special event	Remote video access	—	—	—	—	—	—
Evacuation	Lane reversals	—	—	—	—	—	—
Evacuation	Detours	—	—	—	—	DMS	—
Other	Smoke warning	—	—	—	—	511 website	Motorists are advised of possible heavy smoke on Interstate 10 east and west bound in Santa

Type of Event	Specific Event	Type of Information Presented in Relation to Event Timing				Delivery Method	Example Message
		Hours Before Event	**Minutes Before Event**	**At Time of Event**	**Minutes After Event Started**		
							Rosa County. Use caution.
Other	Road blockage	—	—	—	—	Twitter™	Downed trees are causing issues on I-277 in Charlotte. Crews working to clear road before evening rush hour.
Other	Dangerous road conditions	—	—	—	—	Social media	Magnitude 4.8 earthquake followed by two small jolts strike east of Fresno
Other	Ramp metering	—	—	—	—	CMS	METER ON

—A lack of information was found during the scan. Cells are provided as an indication of considerations to subsequently test.

APPENDIX B. MOBILE APPS FROM STATE TRANSPORTATION DEPARTMENTS AND REGIONAL SOURCES

The following list represents a sample of mobile apps from State transportation departments and other regional sources, which is current as of the publication of this report:

- 511 Georgia & Atlanta Traffic*.[42]
- 511 Wisconsin*.[27]
- PA TURNPIKE TRIP TALK APP.[23]
- Texas Department of Transportation's Drive On.[47]
- WV 511 Drive Safe.[48]
- Florida 511*.[18]
- Idaho 511.[49]
- Iowa 511.[50]
- Lake County PASSAGE*.[45]
- MN 511*.[22]
- MDT Travel Info.[51]
- NM Roads.[52]
- OneBusAway.[53]
- Sigalert.[54]
- Utah Department of Transportation's Traffic.[55]
- VDOT 511*.[46]
- WSDOT*.[26]
- Wyoming 511.[56]

This list is not meant to be comprehensive but rather a sample of the types of mobile apps available for travelers that are provided through State transportation departments and other regional sources. Note that the entries with asterisks are described in more detail in the current report.

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